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VAVASSEUR'S NAVAL GUN CARRIAGE.

A CARRIAGE and brake constructed by Messrs. Vavasseur & Co. is now under trial with the 6 in. new type gun, which promises great things, and which has already proved its excellence in trials made by the Government. Speaking generally, the idea is as follows: There are two cylinders, A and B, Fig. 1, fixed to the carriage, each moving on a piston fixed on a rod, C and D, attached to the slide. Each piston has two openings cut in it, which allow the liquid to pass through from one side to the other of it, but to the piston is attached a disk which moves round so as to close the openings as far as may be desired—Fig. 3. This closing action is effected by a rifled motion imparted to the disk by means of projections running in spiral grooves in the interior of the cylinder. Supposing the piston and rod to be themselves incapable of rotation, then the closing action of the disk would be an unvarying one, depending on the spiral of the grooves. The piston itself, however, can be set in any desired position, so that the openings may be partly closed before recoil, and entirely closed at a corresponding point in the cylinder, so as to limit the recoil absolutely. The value of this can be exhibited by pressure diagrams, which show that with a very reasonable pressure indeed, as shown by the diagram, a very short recoil can be secured. Running up is effected by the gun's own weight, which acts directly a by-pass valve is opened; the rate of running up being limited by the rate of escape of a liquid through the by-pass valve, cannot be quickened inconveniently by the rolling of a ship. The arrangement is, therefore, specially adapted for sea service. The simplicity is apparent on inspection of the actual compressor.

FIG. 2

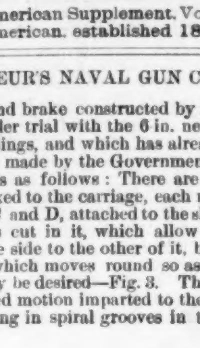
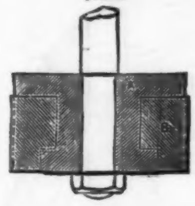


FIG. 3



The tendency to decrease or increase the space available for the liquid in the interior of the cylinders from the exit or entrance of each successive length of piston rod is obviated by attaching one piston rod to the front end, and the other to the rear end of the slide, and making a communication from one cylinder to the other, so that the loss of space in one from the entrance of piston rod is compensated by the corresponding increase of space from the exit of piston rod in the other. E and F, in Fig. 1, are the traversing gear. For a recoil of 36 in. the slide is 9 ft. 6 in. long; for one of 20 in. the slide need not project beyond the breech of the gun. Mr. Vavasseur now proposes to check recoil in about three calibers, though the exact amount is arbitrary according to strength of cylinder. Thus he would pull up a 12 in. gun in 3 ft. For broadside guns, and, indeed, especially in long breech-loading guns, this short recoil gives great advantages. To the underside of the carriage there are fixed two cylinders of wrought iron or steel, similar to the cylinders of hydraulic buffers now in use in the service. These cylinders are connected together at the rear end by a pipe, and are rifled with two helical grooves. Each cylinder is fitted with a piston working freely as in the service hydraulic buffer, on the circumference of which is cut a groove, into which works a gun-metal ring or valve, having two projections working into the two rifled grooves in the cylinders. Across each piston and valve are cut two passages, making two direct communications from one side of the piston to the other. The piston rods of each cylinder are held by brackets fixed one at the front and the other at the rear end of the slide. By means of a short lever and adjusting screw each piston can be moved round its axis and the passages in the pistons placed in any required position with respect to the openings in the valves; by this means the openings for the passage of the liquid from one side of the piston to the other can be enlarged or contracted at will, irrespective of the contraction of the openings due to partial rotation of the valve caused by the rifled grooves during the recoil of the carriage. The piston rods being fixed one to the front and the other to the rear end of the slide, it is evident that as the cylinders move during recoil one piston rod is being withdrawn from one cylinder, while the other piston rod enters the other cylinder, and the liquid thus displaced by one piston rod flows through the pipe connecting the two cylinders, and compensates exactly for the deficiency caused by the withdrawal of the other rod. This arrangement allows both cylinders and connecting pipe to be kept full of liquid, and entirely suppresses all air space. The amount of twist given to the grooves rifled in the cylinders is such that while the passages in the piston may be full open at the commencement, they may be nearly closed at the end of the recoil. To regulate the movement of the gun while running out, a valve is placed in the pipe connecting the two cylinders. This valve opens by the pressure caused in the rear end of one cylinder during the recoil of the gun, and it is evident that when closed so that no liquid can pass from one cylinder to the other, the gun carriage cannot move, as any movement in either direction would be to force one of the piston rods into a cylinder already full. The movements of the valve are controlled by a lever carrying a roller moving on a guide bar placed inside one girder of the slide.

The action of the brake is as follows: The pistons are first adjusted to give the amount of opening necessary for the recoil desired, the amount of opening required of course varying with the charge of powder. As the cylinders move along the slide during recoil, they, by means of the rifled grooves, partially rotate the valves carried by the pistons, and thus gradually contract the openings in the pistons till the gun is brought to a state of rest, where it is kept by the closing of the running out valve which cuts off all communication between the two cylinders. This is effected by an incline on the rear end of the guide bar which controls this valve.

To run out the gun, the incline at the rear end of the guide bar is raised. This opens the running out valve, and the carriage being mounted on rollers the gun runs forward by gravity, if the slide has sufficient incline, or by any suitable mechanical means. The valve is kept open and closed automatically by means of the roller working on the guide bar, which is at that point inclined downward. At the end of recoil the valves never quite close the openings in the pistons, and as the pistons themselves fit easily, there is plenty of room for the flow of the liquid past the piston as soon as the running out valve is opened.

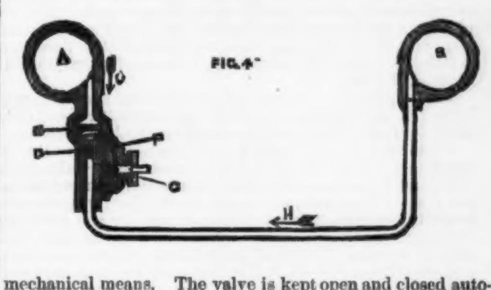
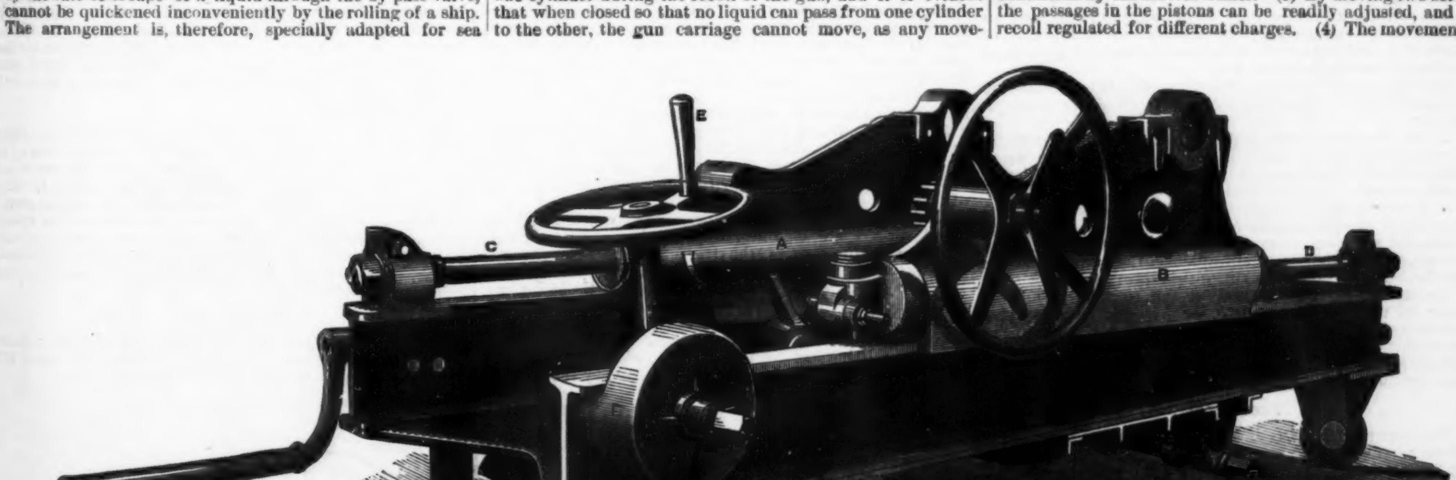


FIG. 4

The advantages claimed for this brake over the service hydraulic buffer are: (1) That the gun is controlled automatically while running out. (2) The openings in the pistons for the passage of the liquid can be made so large at the commencement of recoil in comparison with those of the Woolwich buffer, that it reduces very much the strain on the fighting bolt. In the case of a 24 centimeter French gun, the energy of recoil of which is about equal to the 10 in. 18-ton Woolwich gun, it can be demonstrated that the strain on the fighting bolt, with the compresser above described, is considerably less than one-half of that given under similar conditions by the service buffer. (3) By moving two screws the passages in the pistons can be readily adjusted, and the recoil regulated for different charges. (4) The movement of



IMPROVED NAVAL GUN CARRIAGE AND BRAKE.

the valves regulating the openings in the pistons is so uniform, unvarying, and exact, that there must be great uniformity of recoil, especially as the gun and carriage are mounted on rollers, and the irregularity of recoil avoided, due to the friction of two surfaces sliding one over the other, sometimes clean, sometimes dirty, and sometimes partially lubricated. The advantages claimed for this brake over all others of its class are the entire absence of packings on the pistons, and of valves controlled by springs, difficult of access, uncertain and irregular in their action. It leaves also the carriage free to move at the beginning of the recoil, and does not stop it suddenly at the end, so that all shocks and concussions are avoided.

In our engraving, A, B, Fig. 4, are the compressor cylinders; C, C¹, C², pipe connecting the two cylinders; D, check valve closing, when shut, passage between compressor cylinders; E, stop for check valve; F, passage round check valve or by-pass through which liquid flows to run out the gun to the firing position; G, cock controlling by-pass; H, direction in which liquid flows during recoil; J, direction in which liquid flows while gun is being run out. As the check valve, D, closes by gravity, so soon as the pressure caused by the recoil of the gun ceases, there is no way for the liquid to pass to allow the gun to be run out, except through the by-pass, F, which is controlled by the cock, G. It is proposed to make this passage so small that when the cock, G, is full open the gun cannot run out violently, and when the cock, G, is closed the gun cannot move except toward the rear of the slide or in the direction of recoil.—*The Engineer.*

THE NORDENFELT MITRAILLEUSE.

DURING the last fifteen years or more, the weapons known as "mitrailleuses" have been undergoing gradual improvement. Although there has been some question as to the circumstances under which they could be employed with advantage, it is to-day easy to determine with precision the best possible utilization of the various types which have withstood the test of the most accurate and oftenest repeated experiments. Up to the present time the use of campaign mitrailleuses has been pretty nearly limited to the kind employed in the French army during the late Franco-German war; and the services that these rendered at that time gave, it must be confessed, only a slight idea of what they are capable of doing.

The employment of marine mitrailleuses against torpedo boats is a new application which the increasing speed of the latter, in recent years, has rendered an absolute necessity.

It has been toward supplying this twofold want—the production of a good campaign and a good marine mitrailleuse—that inventors have directed their efforts during the last ten years. To answer all requirements, these weapons must exhibit three characteristic features: rapidity and continuity of firing, simplicity and strength of mechanism, and lightness of weight. The first mitrailleuses (those constructed and experimented with at Meudon) were far from answering these requirements, and for this reason the application that might be made of them was not at first recognized. They were wrongly considered as light artillery pieces, when, in fact, they were only apparatus designed for firing guns rapidly. Moreover, their fire was far from being continuous, they were heavy and unwieldy, and they had the defect—which is a very grave one for an army in campaign—that they required ammunition of a special kind.

After them came the Gattling and other revolving mitrailleuses. These marked a further progress; they were capable of being fired more rapidly than those that had preceded them, but their mechanism was somewhat complicated. The new Nordenfelt-Palmerantz mitrailleuse, which is represented in Figs. A and B, in its two forms, designed respectively for service on sea and on land, possesses over other similar apparatus certain theoretical advantages which are easy of demonstration and which practical experiments have in every respect justified.

We shall describe it, and indicate in detail the results that it has yielded in competitive trials with its rivals, and we shall close by enumerating the applications which may be made of it, and the nature of the services that it is capable of rendering both on land and sea.

Let us remark, in the very first place, that this mitrailleuse is characterized by the two following prominent arrangements:

1. Mr. Nordenfelt uses, instead of a hand crank for working his mitrailleuse, a horizontal lever, which comes much more natural to the hand of the operator and permits of greater rapidity of firing being attained.

2. For each gun he employs a separate mechanism, which is arranged in such a manner as to permit of the firing being continued while one or more of the mechanisms are out of service, while in all other mitrailleuses the stoppage of the mechanism puts the entire apparatus out of service.

To explain the construction of the Nordenfelt mitrailleuse, let us take, for example, the four-gun marine type, carrying a one-inch steel ball. What we shall have to say about this will apply equally well to the ten-gun campaign mitrailleuse, the ammunition for which is the same as that used by the infantry.

DESCRIPTION.

The apparatus consists of four barrels, fixed in a horizontal plane to a rectangular iron frame, whose sides are connected by three cross pieces. The guns are set into the posterior cross piece, N, and are screwed into the middle one, C.

The lock, K, which has only a backward and forward motion, is placed between the back and middle cross pieces. In front of it are screwed four steel plungers, 26, each of which corresponds with one of the barrels. They are provided at their right side with a shell extractor, 28, and behind each of them there is a hammer, 24, having a chamfered base, against which presses a spiral spring, 23.

Beneath the lock are: (1.) A slip bolt cam, 37, pivoting on its axis, 38, and which, through the medium of two slots, moves the double bolts, 36, in and out. (2.) The piece, 35, which is fixed to the lock and carries a slot in which slides a roller, 51, mounted on a pin on the shifting bar, P. A portion of this slot has the form of an arc of a circle, whose axis is the center of the axle of the maneuvering lever, O; the other portion is rectilinear, so that when the shifting bar moves from right to left, the lock moves forward.

Upon a support fixed to the back cross piece, N, moves the trigger plate, M, which has a transverse motion and carries four tumblers, 43. This plate is thrust to the left by a powerful spring, 48, which is connected with the back cross piece. The carrier, L, is of cast iron; it contains four longitudinal apertures to allow the shells to pass after they have been extracted, and carries a receptacle, 17, for holding the cartridges during loading.

It has a backward and forward motion, which is communicated to it by the lever, 41, moving freely on the axle, 52, of the maneuvering lever, O, through the action of the guide-roller, 39, fixed underneath the lock. The whole mechanism is put in motion by the maneuvering lever, O, which is keyed to the axle, 52.

The carriage of the mitrailleuse is shown in Figs. A and B. The trunnions are supported by the arms of a strong swivel, which is pivoted on a conical base that may be located at any point on the vessel from whence it is desired to fire.

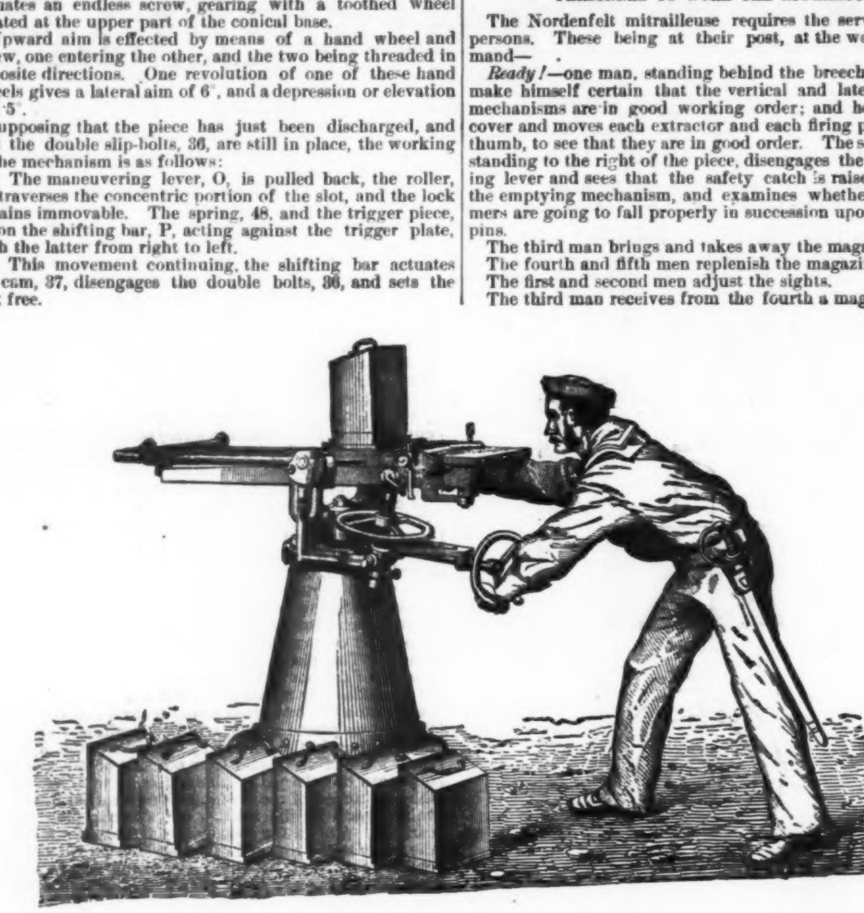
Direct aim is obtained by means of a hand wheel, which actuates an endless screw, gearing with a toothed wheel located at the upper part of the conical base.

Upward aim is effected by means of a hand wheel and screw, one entering the other, and the two being threaded in opposite directions. One revolution of one of these hand wheels gives a lateral aim of 6°, and a depression or elevation of 1·5°.

Supposing that the piece has just been discharged, and that the double slip-bolts, 36, are still in place, the working of the mechanism is as follows:

1. The maneuvering lever, O, is pulled back, the roller, 51, traverses the concentric portion of the slot, and the lock remains immovable. The spring, 48, and the trigger piece, 53, on the shifting bar, P, acting against the trigger plate, push the latter from right to left.

2. This movement continuing, the shifting bar actuates the cam, 37, disengages the double bolts, 36, and sets the lock free.



NORDENFELT MITRAILLEUSE.—FIG. A.—MARINE TYPE.

3. At the moment the bolts are drawn back the slide, 51, traverses the rectilinear portion of the slot, and the lock begins to move backward, drawing along with it the plungers, whose extractors draw out the exploded cartridge shells.

4. The plungers once disengaged, the guide roller of the lock slides along the lever, 41, and pushes the carrier to the left. At the same time the corner of the trigger piece, acting against the chamfer, 42, carries the trigger plate to the right. The empty shells then fall to the ground, to be replaced by cartridges from the magazine. The chamfered bases of the hammers pass behind the tumblers of the trigger plate, which is pushed to the left by the spring, 48, when the trigger piece or lug, 53, is drawn back. The lever, O, being now at the extreme end of its backward course, is again pushed forward, with the following results:

1. The slide, 51, of the shifting bar, P, by its movement in the slot, pushes the lock forward; and the guide roller, 39, bearing on the lever, 41, moves the carrier to the right and brings the cartridges into the prolongation of the axis of the guns.

2. The lock continues its forward movement, and the spiral springs are compressed by the hammers, which are held by the tumblers of the trigger plate. The plungers then push the cartridges into the barrels.

3. When the cartridges are exactly in place, the lock stops, and the guide roller, acting on the cam, 37, causes the bolts to enter the apertures made to receive them in the frame. The breech is thereby securely fastened.

4. The shifting bar then carries the trigger plate toward the right, and each hammer, being set free by the tumbler which is holding it, starts forward, strikes against the firing pin, and explodes the cartridge.

The apparatus is also provided with a safety-catch for stopping the maneuvering lever before it reaches the end of its travel, so that the hammers cannot pass behind the tumblers of the trigger plate, nor the spiral springs be cocked while the lock is moving forward.

The breech sight, F, is graduated up to a range of 5,400 feet, and may be raised or lowered by means of a rack and pinion.

PERSONNEL TO WORK THE APPARATUS.

The Nordenfelt mitrailleuse requires the service of five persons. These being at their post, at the word of command—

Ready!—one man, standing behind the breech, must first make himself certain that the vertical and lateral aiming mechanisms are in good working order; and he raises the cover and moves each extractor and each firing pin with his thumb, to see that they are in good order. The second man, standing to the right of the piece, disengages the maneuvering lever and sees that the safety catch is raised, operates the emptying mechanism, and examines whether the hammers are going to fall properly in succession upon the firing pins.

The third man brings and takes away the magazines.

The fourth and fifth men replenish the magazines.

The first and second men adjust the sights.

The third man receives from the fourth a magazine, puts it in place, and busies himself with the left-hand breech sight. The first man aims the mitrailleuse, for this purpose making use of the left-hand breech sight, and actuating the lateral-aim hand wheel with his right hand, and the upward-aim hand wheel with his left hand.

At the command—

Fire!—the second man pulls the maneuvering lever back as far as it will come, then pushes it forward half way, and, at the command "Fire," he continues to push it forward till all the cartridges are exploded. Then he draws the lever back as far as it will come and recommences the operation. When the magazine is empty, the third man replaces it by another, and hands the empty one to the fourth and fifth men to fill.

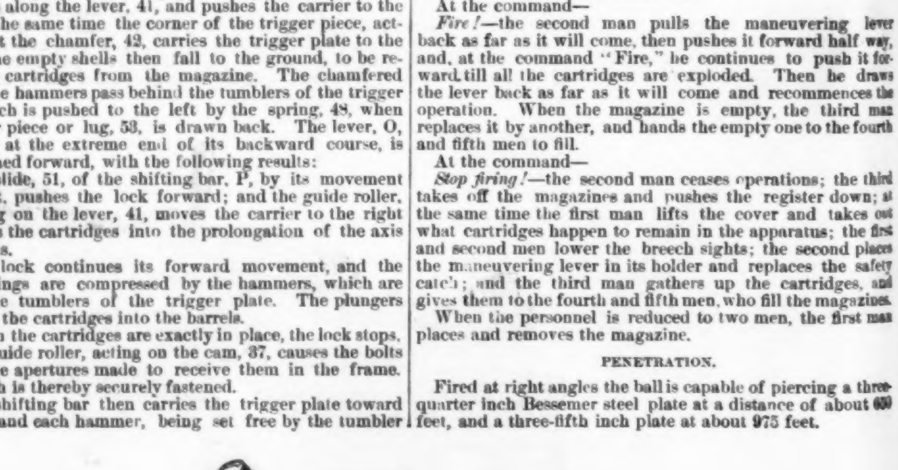
At the command—

Stop firing!—the second man ceases operations; the third takes off the magazines and pushes the register down; at the same time the first man lifts the cover and takes out what cartridges happen to remain in the apparatus; the first and second men lower the breech sights; the second places the maneuvering lever in its holder and replaces the safety catch; and the third man gathers up the cartridges, and gives them to the fourth and fifth men, who fill the magazines.

When the personnel is reduced to two men, the first man places and removes the magazine.

PENETRATION.

Fired at right angles the ball is capable of piercing a three-quarter inch Bessemer steel plate at a distance of about 600 feet, and a three-fifth inch plate at about 975 feet.



NORDENFELT MITRAILLEUSE.—FIG. B.—CAMPAIGN TYPE.

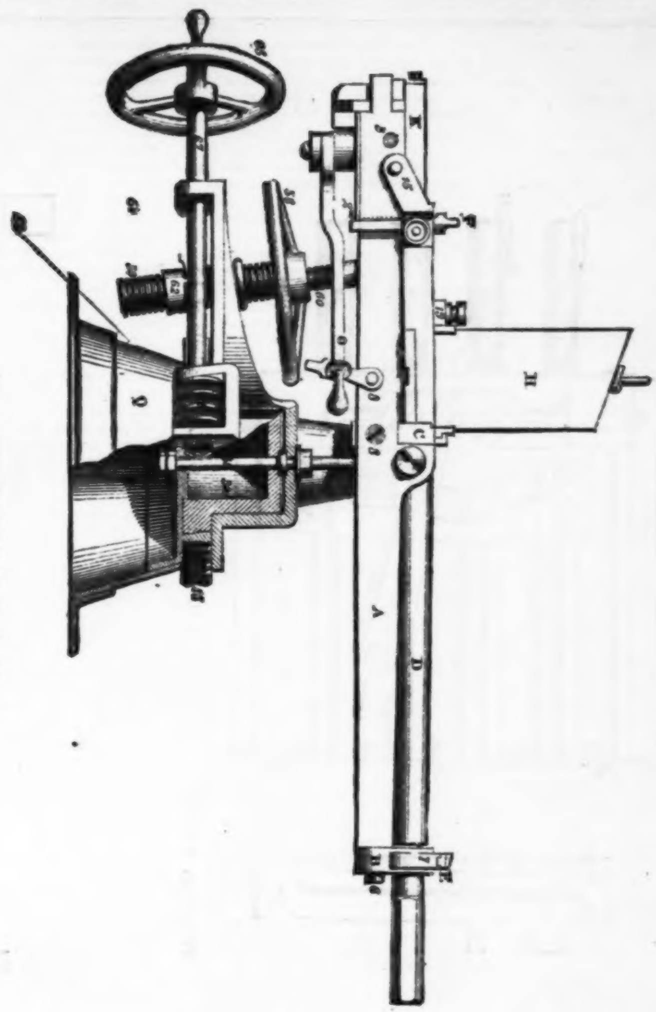


FIG. 1. ELEVATION. (Scale of 1/10.)

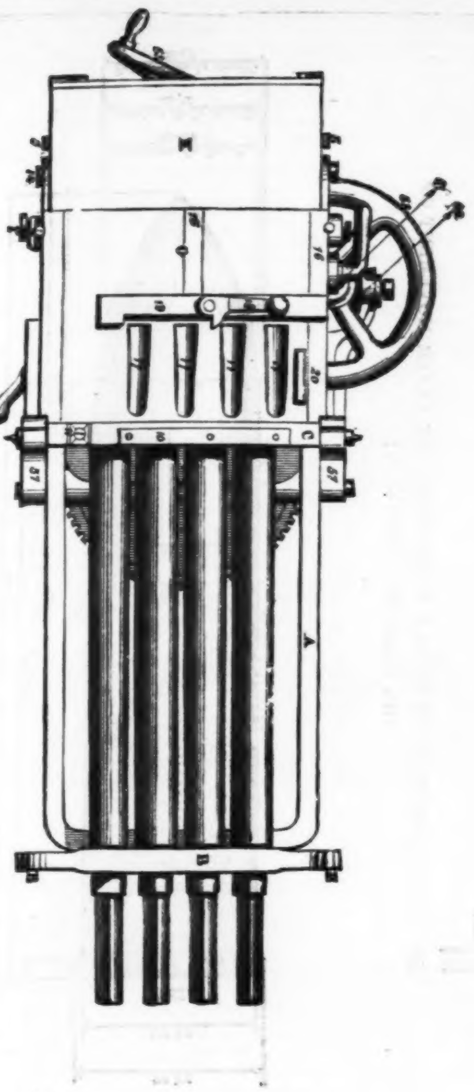


FIG. 2. PLAN VIEW. (Scale of 1/10.)

NORDENFELT MITRAILLEUSE.

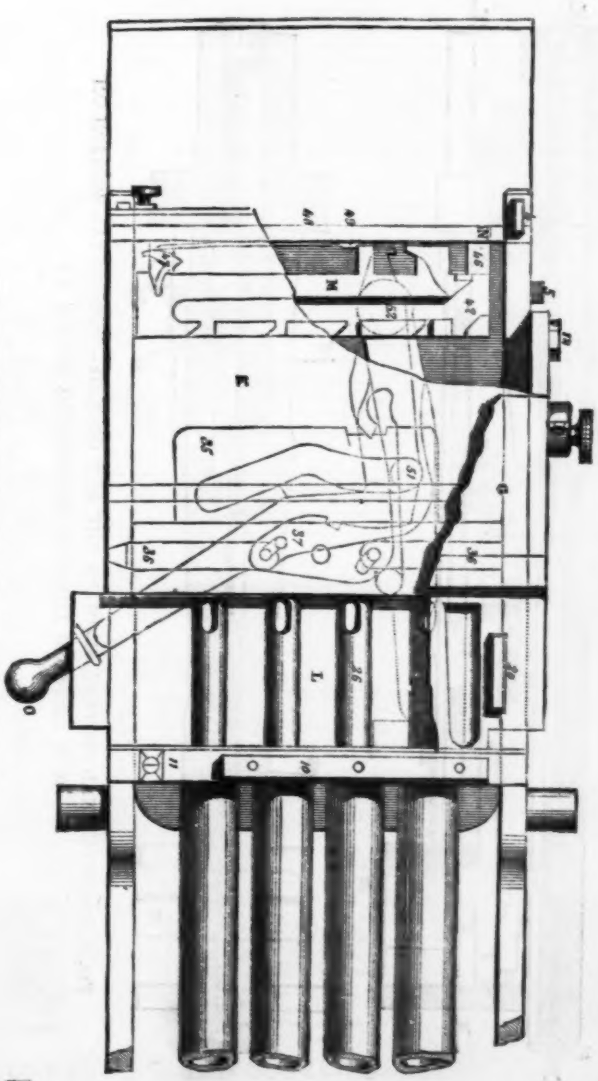


FIG. 3. PLAN OF LOCK AND PLUNGERS. (Scale of ¼.)

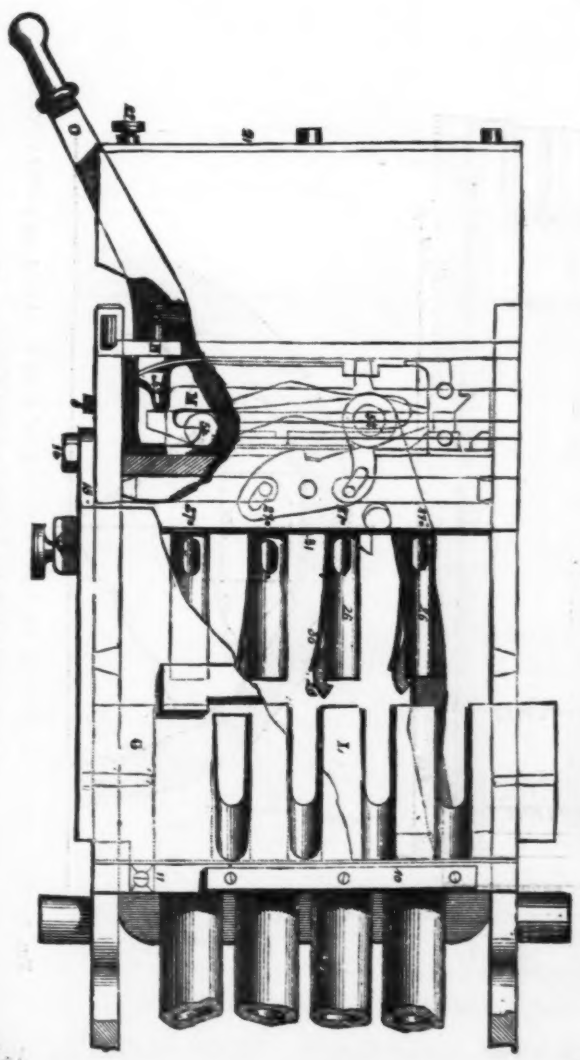


FIG. 4. PLAN OF LOCK AND PLUNGERS. (Scale of ¼.)

NORDENFELT MITRAILLEUSE.

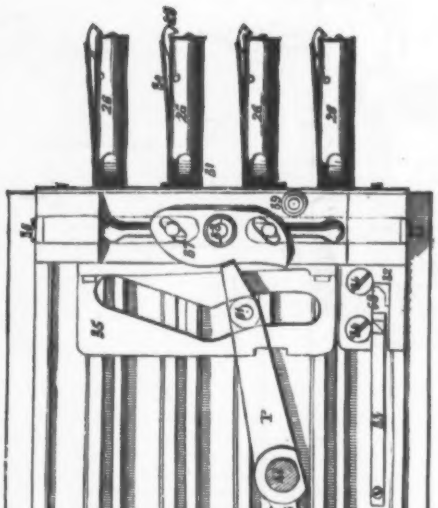


FIG. 5. UNDER SIDE OF LOCK. (Scale of ½.)

TRIGGER PLATE.

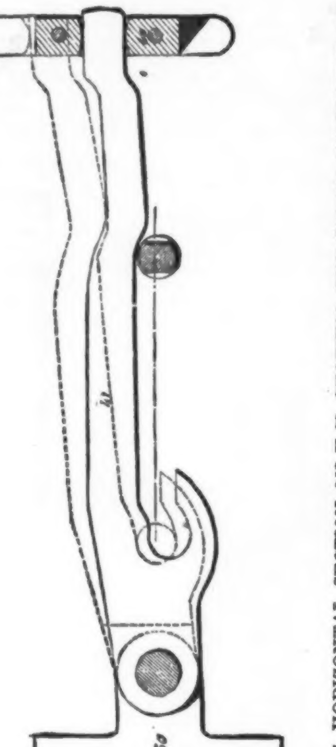


FIG. 7. HORIZONTAL SECTION ON X Y, SHOWING THE LEVER MOVEMENT OF THE CARRIER (Scale of ¾.)

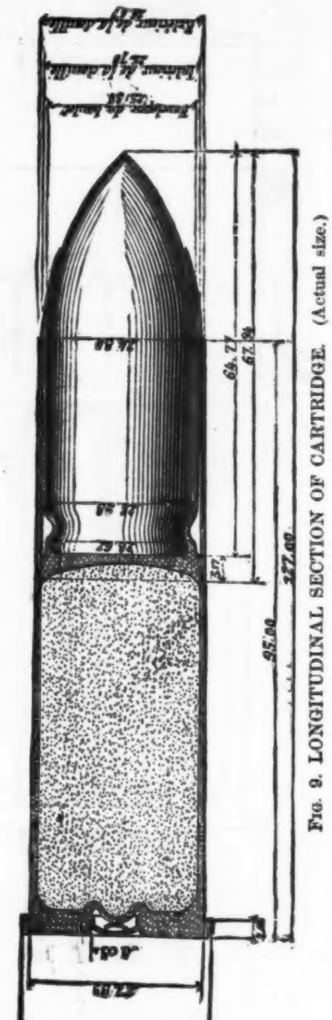


FIG. 9. LONGITUDINAL SECTION OF CARTRIDGE. (Actual size.)

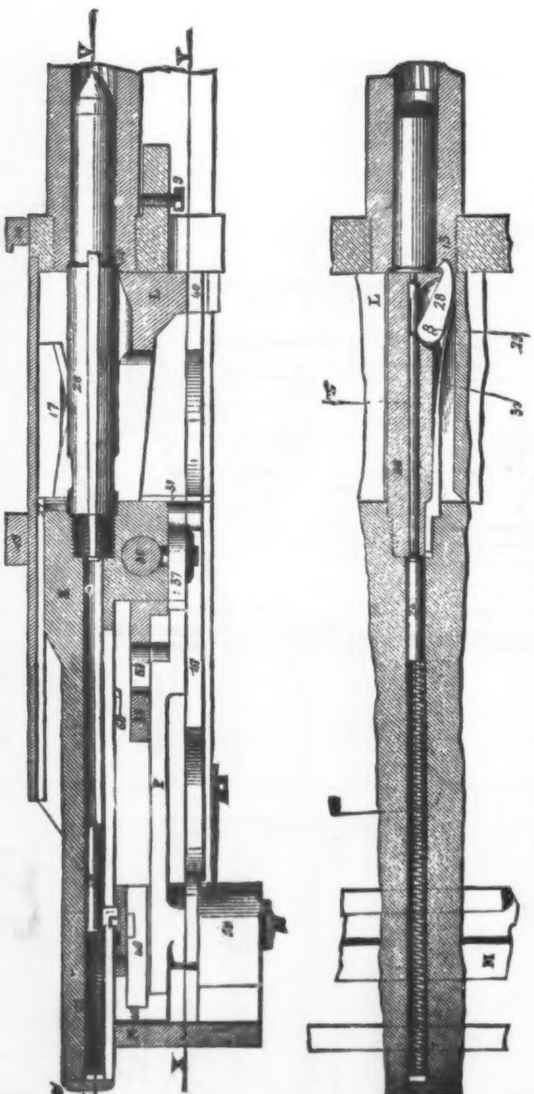


FIG. 6. LONGITUDINAL SECTION, SHOWING THE GUN COCKED.—HORIZONTAL SECTION ON W V, SHOWING THE GUN DISCHARGED. (Scale of ¼.)

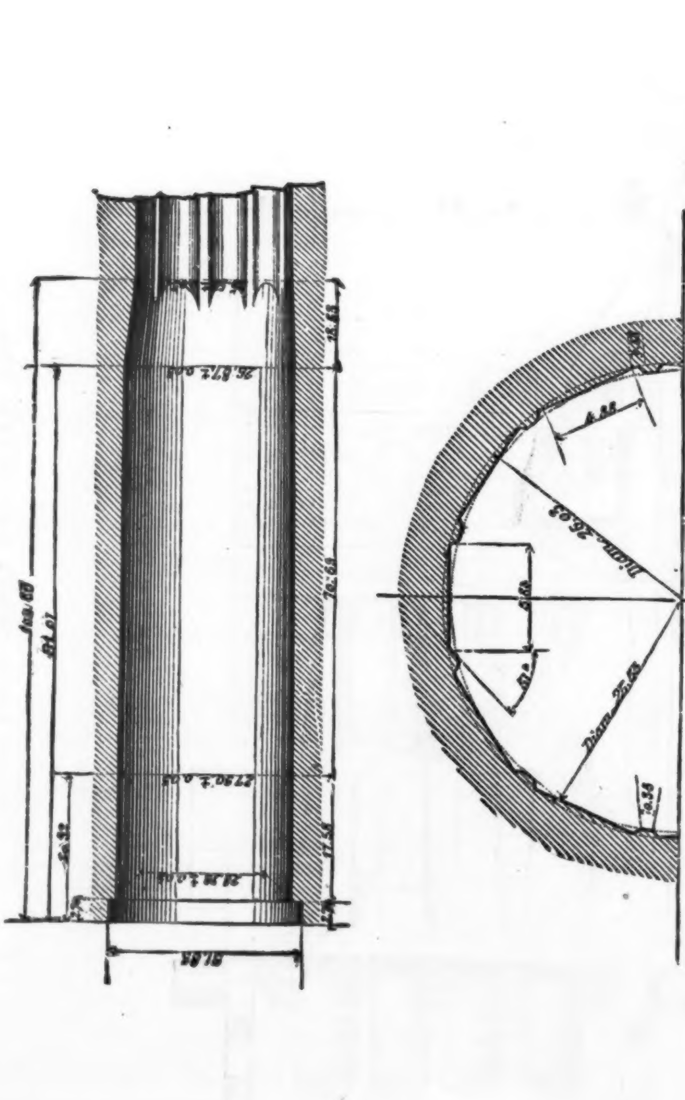


FIG. 8. LONGITUDINAL SECTION OF THE CHAMBER OF A GUN. (Actual size.)—TRANSVERSE SECTION OF BARREL. (Scale of ½.)

AMMUNITION.

The general form and dimensions of the cartridge are shown in Fig. 9.

The charge of powder weighs 625 grains, and is compressed into the shell, care being taken that it shall always occupy the same space. The object of compressing it is to crush the weaker grains and to form a solid mass of dust with grains interspersed.

The ball, which is of steel, weighs 8 ounces and 133 grains, and its conical head is tempered. At its base there is a groove into which the brass envelope of the projectile is pressed, and on the bottom there are star-shaped striæ, into which the envelope enters when the projectile is fired.

The space between the envelope and the interior of the shell is filled in with pure wax, which serves as a lubricant.

The rotary motion of the projectile is given by the envelope, which is of very thin brass, with a concave butt, its upper part being carefully fitted to the head of the ball.

PRINCIPAL DATA.

Total weight	800 pounds.
Weight of mitrailleuse	427 "
Weight of carriage of marine type	356 "

Guns.

Number of guns	4
Caliber	1 inch.
Total length of gun	3 feet.

Magazine.

Number of compartments in magazine,	4
Number of cartridges per compartment,	10
Weight of magazine, empty	20 pounds.
Weight of magazine, filled	48 "

Projectile.

Total weight of steel projectile	8·27 ounces.
Weight of envelope of projectile	0·8 ounce.
Weight of charge	1·6 ounces.
Weight of shell	2·5 "
Total of weight of cartridge	13·17 "
Number of cartridges per mitrailleuse	7,680
Number of cartridges per box	93
Weight of box, filled	84 pounds.

Aim.

Maximum angle of positive aim	17°
" " negative aim	30°

LUNDBORG'S HIGH SPEED STEAMSHIPS.

THE proposals which have recently been put forward for the construction of a fleet of high speed Atlantic steamers; the launch of the City of Rome; the building of gigantic ships by the Guion and Cunard companies, all point the same way, and indicate the existence of a desire to place England and America virtually yet closer together than they are now. In certain respects the problem to be solved is very simple. Most of the conditions to be fulfilled are perfectly understood. An average speed of at least twenty miles an hour must be maintained incessantly while a storm-swept ocean, 3,000 miles broad, is being traversed. It is known that there is no possibility of doing this with vessels of less than 5,000 tons displacement, and it is nearly certain that much more will be required. An average speed of twenty miles means that a higher velocity than this must be attained now and then when wind and sea are not dead against the ship. Thus it comes to pass that the express Atlantic steamer of the future must be a vessel of enormous engine power. We have already pointed out the great difficulties that stand in the way of utilizing 14,000 or 15,000 indicated horse-power at sea. It will be readily conceded that, although the conditions of success are, as we have said, known, the means of securing these conditions have not been settled. It is evident, however, that it is of the utmost importance that the resistance of the ship should be as small as possible. Now the late Mr. Froude taught the world a lesson which has often been misunderstood. He pointed out that the form of a ship's hull had little or no effect on the power required to propel her, and in saying that he was quite right in one sense; but he did not stop there. He added that eddy making was the great source of resistance, and eddy making depends very much indeed on the shape of a hull. To eddies and skin friction the whole, or very nearly the whole, resistance of a ship may be attributed, but these are both largely dependent on the shape of a ship's hull. Now it is not perhaps too much to say that no further progress is possible in the direction of reducing the resistance of ships, so long as we adhere to existing models. The London and North-Western Railway Company's Holyhead steamer Violet is probably at this moment the fastest steamship in the world. She has attained a velocity not much less than that of torpedo boats, but no express Atlantic steamer could be built like her. The Violet is a paddle boat, and what will suit paddles will not answer for screws. A new departure is necessary.

We illustrate a design prepared by Captain C. G. Lundborg, of Sweden, a naval architect, and we give prominence to this design, because it appears to us to be full of promise. It has been argued that the design is not a good one for a cargo steamer, and we concede at once that it is not worth while to build a steamer of this type to attain a speed of eight or nine knots. Our readers, we must ask to bear in mind, have before them a design for an Atlantic passenger steamer, which, while affording ample space for passengers and valuable cargo, has been prepared with the primary object of attaining a velocity of twenty to twenty-one knots an hour, with a comparatively moderate expenditure of power. Our engravings show the form of the ship so fully that little or no description of any kind is necessary. It will be seen that the prominent idea involved is that of making the main body of the ship divide the water horizontally instead of vertically. It will perhaps be conceded without much hesitation that by adopting this system of construction it becomes possible to build a ship of the greatest capacity for a given draught—an advantage which speaks for itself. But besides this it is also evident that this ship of shallow draught and great capacity can have admirable lines. In other words, her resistance may be reduced to a minimum. The principle admits of the naval architect imparting to his ship a splendid clean run aft, and the screws can be carried far astern and yet be perfectly supported. The advantages to be derived from thus placing the screws far astern have been insisted on by the late Mr. Froude. It will also be seen that no scheme has ever before been put forward which is so perfectly adapted to the use of twin screws. When it is desired, the stern of the ship can be carried further aft, as shown by the dotted lines, to protect the screws; but this would probably be unnecessary. It will also be seen from the cross section that there is ample room provided for engine power, notwithstanding the excessively fine run of the hull aft. The accompanying table contains the calculations on which the anticipated performance of the ship is based.

Synopsis of Description and Calculations relating to an Ocean Steamship upon new designs.

Extreme length	500	feet.
" breadth	74	"
" depth amidships from top of rail	45·5	"
Length on load water line	450	"
Breadth on load water line	56	"
" on upper deck (outside of frames)	63	"
Depth below load water line (draught of water)	24	"
Depth of extreme forward end (horizontal cutwater)	13	"
Depth of stern	13	"
Depth of lower part of the hull (midship section) from outside of bottom plating to top of main deck beam	23·5	"
Depth from skin to main deck beam	19·5	feet.
Height between the decks	9·83	"
Area of midship section below load water line (greatest immersed transverse area) =	1,474 sq. ft.	
Coefficient of greatest immersed transverse area =	0·830	
Area of load water plane =	18,154 sq. ft.	
Coefficient of load water plane =	0·720	
Displacement to load water line =	523,980 c. ft.,	
=	14,971 tons.	
Coefficient of fineness of displacement =	0·590	
Distance of center of buoyancy from stern =	253·76	feet.
Depth of center below load water line =	11·673	"
Height of metacenter above center of buoyancy =	7·252	"
Height of metacenter above center of gravity of the ship when fully equipped and loaded =	4·037	"
Wet surface when immersed to load water line =	52,554 sq. ft.	
Angle of obliquity at entrance and run =	6 deg. 40 min.	

The ship is to have two propellers of 20 ft. diameter and 30 ft. pitch. The propelling power to consist of four compound engines, two on each propeller shaft, developing each, when making 80 revolutions per minute, 5,700 indicated horse power, or for all four engines together 22,800 indicated horse-power.

With this power the speed, according to Professor Rankine's formula, would be 20·2 knots per hour; but that speed would in all probability be exceeded, as little power will be lost by wave-making, the water having a clean run astern, being divided horizontally by the lower part of the hull.

The ship would have room to accommodate about 600 first class and 1,500 second and third class passengers, and carry 3,000 tons of cargo (or 4,000 tons if loaded to 26 ft. draught of water), besides 3,200 tons of coal, sufficient for 180 hours if steaming at full speed.

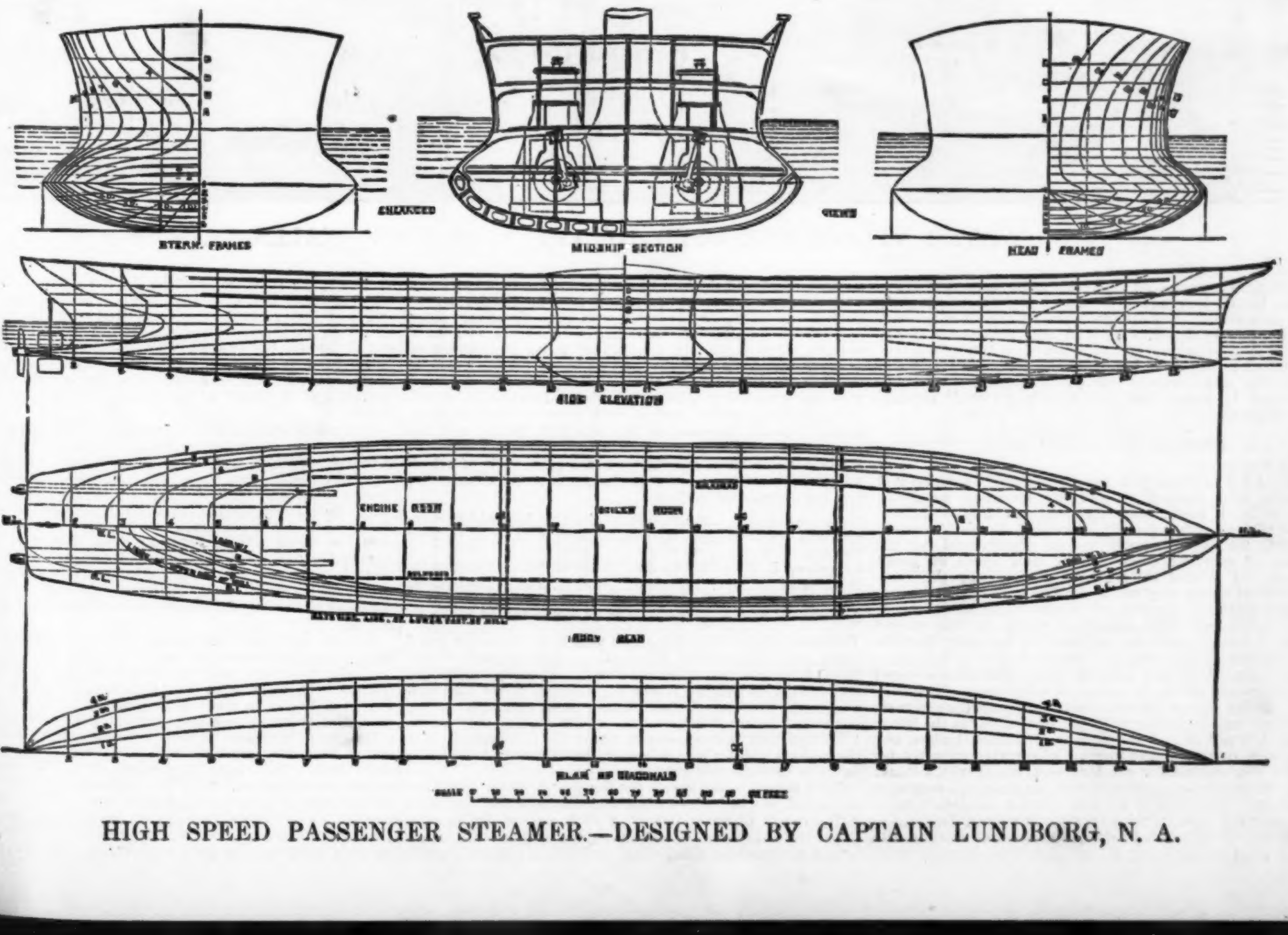
The great height of the metacenter above the center of gravity of the ship would safely permit yet another deck to be added, even with the unusual height of more than 9 ft. between the decks, thus largely increasing the space and giving room for a much greater number of passengers.

The ship is designed to be built of iron or steel, with a double bottom up to the angle of greatest beam at 13 ft. below the load water line, and with a great number of watertight compartments, transverse and longitudinal.

The weights of the parts making up the displacement and their distribution are as follows:

Weight of ship's hull	4,579	tons.
" on main deck (cabin fittings, passengers, etc.	237	"
Weight on spar deck, do	212	"
" on upper deck (deck-houses anchors, winches, boats, steering gear, etc.)	140	"
Weight of masts, spars, and sails	100	"
" watertanks and water	190	"
" provisions and stores	100	"
" hemp and chain cables (besides those on upper deck)	21	"
Weight of engines and boilers, with water	3,150	"
" funnels and ventilators	40	"
" coals	3,200	"
" cargo	3,002	"
Total	14,971	tons.

In calculating the center of gravity of the ship, due care has been observed not to get it too low down, so that the height of the metacenter above that point may be relied upon as being at least as much as stated. The stability, as will readily be seen by the form of the lower part of the



HIGH SPEED PASSENGER STEAMER.—DESIGNED BY CAPTAIN LUNDBORG, N. A.

hull, is very great, increasing rapidly after the first few degrees of heel.

As the result of the calculations as stated above can easily be verified by our engraving, we will only add the calculations as to the speed:

Wet surface................ = 52,554 sq. ft. = S
Mean angle of obliquity..... = 6 deg. 40 min. = φ

$$\text{Rankine's formula: } v = \sqrt[3]{\frac{20{,}000 \times \text{H.P.}}{S\,(1 + 4\sin^2\phi + \sin^4\phi)}}$$

Sin 6 deg. 40 min. = 0·1161; sine^2 ϕ = 0·013479

$$\begin{array}{r} 0{\cdot}013479 \\ 4 \\ \hline 4\sin^2\phi = 0{\cdot}05391 \\ \sin^4\phi = 0{\cdot}00018 \\ 1{\cdot}00000 \\ \hline 1{\cdot}05409 \end{array}$$

Augmented surface = 52554 × 1·05409 = 55396

$$v = \sqrt[3]{\frac{20{,}000 \times 22{,}800}{55396}} = \sqrt[3]{8231} = 20{\cdot}2$$

Hence the speed = 20·2 knots per hour.

The projection of the hull below water will go far to secure immunity from rolling, and presents no difficulties of construction which cannot easily be overcome, while it will tend to give a strong ship as well as one which will be fast.

In conclusion, we may point out that we have in Captain Lundborg's design, one which gives a ship with exceedingly fine lines and the smallest possible amount of what has been termed by Rankine "augmented surface," whenever the size of the ship is such that the draught can be about half the beam. Captain Lundborg's patents have only been completed within the last two months, but his designs have been very favorably received by several eminent authorities both in this country and the United States. Capt. Lundborg's designs are not only the result of mathematical investigation, but of long and skillfully conducted experiments, which gave without any exception results always in favor of Capt. Lundborg's model. We trust that the merits of the design will soon be brought to a practical test by the construction of a steamer of moderate size. It is impossible to overrate the importance of the problem which we dare to think Capt. Lundborg has gone some way toward solving.—*The Engineer.*

HIGH SPEED STEAMSHIPS.

To The Engineer:

While I beg to thank you for the honorable mention that you have been pleased to give my invention regarding ships' hulls, I would respectfully remark that, although, as you have very properly observed, it would hardly be worth the while to build vessels of this kind for the purpose of carrying cargo at the slow speed of about 8 knots, yet I can see no good reason why the same principles of design may not be applied with advantage also to cargo steamers, particularly where speed would be of some importance. The objections raised in this respect regard, I believe, only the first cost of building; but this extra expense if any, would, I am convinced, be more than counterbalanced by the superior speed that such a vessel certainly would attain, as compared with others of ordinary form having equal displacement and propelling power; which, *per contra*, would, with the same speed as the latter, require less power and less weight of engines, boilers, and coals, with corresponding increase of carrying capacity for cargo. The reasons for greater speed, which will, I think, appear obvious upon examination of the designs, I may state as follows: The form of the hull makes it possible to unite great carrying capacity with very fine lines and the greatest sharpness. It also admits of the finest and cleanest run astern possible, allowing the propellers to develop their utmost effect, working always in unbroken solid water, thus avoiding the loss of power due to their ordinarily disadvantageous position in close proximity to the sternpost and rudder, and the overhanging part of the ship's stern, against which the sea strikes when the ship is pitching, causing a disturbance unfavorable to the continuous grip of the propellers upon the water.

Such a vessel must glide easily through the water, creating very little wave at its bow and stern as the main body of the hull divides the water horizontally below the surface, which will be disturbed only by the upper part of the hull that divides the water vertically; but as that part of the hull may also be very sharp, and as it constitutes only a small part of the displacement, there will be less wave-making during the vessel's progress, and a consequent economy of power in comparison with ordinary ships. Such a vessel must be comparatively steady in a sea-way, rolling and pitching less than others of the usual type, on account of there being a considerable body of water above the projecting angular sides of the hull, which body of water must, when the ship rolls, be elevated on one side while the other side is being depressed. In moderate weather, when the upper strata of the sea only are disturbed by the force of the wind, there will scarcely be any motion felt from the sea, except that which might be due to a ground swell caused by previous gales. This steadiness during the vessel's progress will save power in no inconsiderable degree. The rudder—which may be nearly perfectly balanced, so as to require little power to move it—may have much less area than in vessels of the usual model and yet be more effective, requiring less angular motion to swing the ship's stern, which presents a favorable form and comparatively small vertical surface to be moved sideways. The resistance to the ship's progress caused by the rudder being diminished in proportion to its area, a corresponding economy of power will follow.

Owing to the large displacement caused by the width of the submerged part of the hull all the way astern, in conjunction with the great sharpness of entrance and run, the augmented surface will compare favorably with that of ordinary ships of equal displacement, particularly when, as you have already pointed out, the draught of water approaches or somewhat exceeds half the greatest beam. As an example to illustrate this, I may cite the steamship Charles V., a vessel of beautiful proportions, having admirable lines and very small augmented surface with respect to her displacement. The displacement of that ship is 2,478 tons, and the augmented surface 15,266 square feet. Below I give the dimensions of three vessels upon my plan, each of which would have quite as large displacement as the Charles V., but less augmented surface:

Extreme length	210 ft. 0 in.	203 ft. 5 in.	224 ft. 0 in.
Extreme breadth ..	35 ft. 0 in.	40 ft. 6 in.	37 ft. 3 in.
Draught of water...	20 ft. 4 in.	20 ft. 3 in.	18 ft. 3 in.
Length on L. W. L.	192 ft. 5 in.	182 ft. 0 in.	204 ft 5 in.
Breadth on do......	28 ft. 0 in.	32 ft. 5 in.	29 ft. 9 in.
Displacement.........	2,510 tons	2,482 tons	2,484·5 tons.
Augmented surface...	13,990 sq. ft.	14,638 sq. ft.	14,827 sq. ft.

The power required to drive two vessels at the same speed being very nearly in the same ratio as their augmented surfaces, it follows that when the Charles V. makes a certain speed with an engine power of, suppose, 2,000 indicated horses, the first one of these three vessels, although having somewhat larger displacement, would require only about 1,833 indicated horse-power to make the same speed. For the reasons stated above, however, the difference would probably be considerably greater.

With regard to the vessel, the designs of which you have published, it will be seen from what has been said that with 26 ft. draught of water, instead of 24 ft. and less beam, so as to yet have the same displacement, the augmented surface would be somewhat diminished, and in this respect I would remark that the designs were prepared with special regard to great stability, sufficient to allow yet another deck above the upper one, shown on the drawing. If the ship was loaded down to 26 ft. draught, thus making the displacement about 16,030 tons, the speed would still certainly exceed 20 knots; and if the engine power was reduced to 16,000 indicated horse-power—two engines, each of 4,000 indicated horse-power on each propeller shaft—instead of 22,800 as proposed, the speed would probably reach 19 knots, while the carrying capacity for cargo, besides a full complement of passengers, would be about 6,000 tons.

C. G. Lundborg.

London, June 28.

A WATER VELOCIPEDE.

The beautiful piece of ornamental water, situated near Egham, in Surrey, on the south-east border of Windsor Park, was constructed in the reign of George II., by order of the Duke of Cumberland, then Ranger of Windsor Park. His Royal Highness was sometime Governor of Virginia, when that territory, which is now one of the United States, was a colony subject to the king of Great Britain. In commemoration of this dignity, the name of "Virginia Water" was bestowed on the pretty artificial lake, which was formed under the direction of Paul Sandby, an eminent landscape artist and landscape gardener, by turning the small streams of the district into a basin partly natural, but deepened and widened, extending a mile and a half in length. The banks of this lake, which are included within Windsor Park, are planted with groves, interspersed with lawns, presenting a very agreeable aspect, but it is a question of taste whether they are much adorned by some of the buildings which George IV. caused to be erected here. There is the Hermitage, on a slight eminence overlooking the water; the Chinese pagoda, with a gallery from which George IV. used to cast his line in the sport of angling; the Belvedere, a triangular building with turrets, armed with a battery of old guns; and the mimic ruins of a Grecian colonnade, the materials of which are marbles brought from Tunis. At the lower end of the lake is a cascade, by which its waters are poured into a passage underneath the Bagshot road, to reach the Thames at Chertsey; and here is a grotto, formed of the materials of a Druid stone cromlech found on Bagshot Heath.

Virginia Water is still a favorite resort of the Royal family whenever they are in the neighborhood; and the Prince and Princess of Wales, with their children, have now and then enjoyed a picnic party there, and embarked upon the lake. During their stay at St. Leonard's Hill, for the Ascot Race week, their Royal Highnesses came to spend a few hours of the evening at this pleasant summer retreat. Upon the last occasion, which was on Saturday week, they went out in a rowing-boat, followed by the ladies and gentlemen of their party in a variety of skiffs and other craft decked with bannerets, which were briskly navigated up and down, while the band of the Royal Horse Guards enlivened the fête with music.

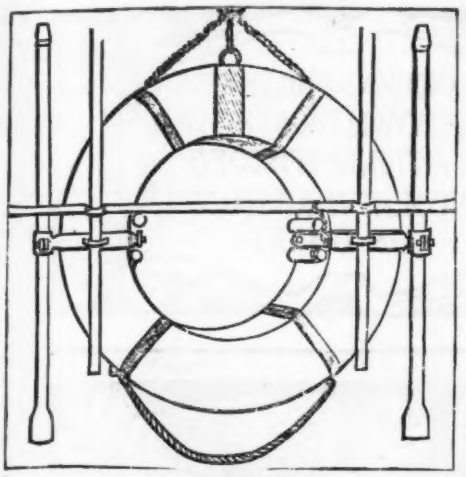
But the ingenious contrivance styled a "water velocipede," which is shown in our engraving, was not absent from the miniature fleet on Virginia Water, and it has frequently been worked by the Princess as well as by the Prince of Wales, in their more private hours of open-air recreation there, as well as in garden parties elsewhere. It is the patent invention of Messrs. Searle & Sons, boat builders, of Stangate, Lambeth, who have made these machines since 1869. They have been supplied to Virginia Water, and to the ornamental water in the gardens of Buckingham Palace; also to those of Kensington House, where they were used at the bachelors' ball and at the Atalanta fête; and to those of the Marchioness of Camden, at Bayham Abbey, recently visited by the Prince of Wales. His Royal High-

WATER VELOCIPEDE USED BY THE PRINCE OF WALES.

ness is said to like sometimes using a particular machine for a single person, being thus enabled to get himself a little apart from the numerous suite or party of friends attending his presence. The Princess of Wales has no difficulty in working the apparatus, to indulge herself and two or three of her young daughters with a little trip over the smooth water. There is, indeed, nothing laborious in the exercise, which is merely a slight treading action of the foot, leaving the hands quite free for the steering ropes. The operator sits rather high, and has perfect command over the movements of the light vessel. A speed of four miles an hour can be maintained a long time, in the "water velocipede," without much fatigue.—*Illustrated London News.*

A NEW LIFEBUOY.

AN interesting experiment was lately witnessed off Erith by the officers studying at the Royal Naval College with a new



THE NEW BUOY.

lifebuoy designed and patented by Robert Whitby, late gunner's mate of H. M. S. Excellent. The trial was made from

THE MAN INSIDE.

H. M. gunboat Trent. The buoy, which consists of a hollow cylinder in circular form, with air-tight compartments, was dropped into the water, and a man plunged in after it; he swam to the buoy, and seizing it, turned one side over his head, thereby placing himself within the circle; he then secured himself in an easy position, his back resting on the inside of the buoy, the weight of the body being partly supported by a chain or foot-rope for the feet to rest in; his arms were then comparatively free for signaling to the ship. One advantage claimed for this buoy is that in heavy weather, when it might be dangerous to lower a boat, it can be picked up by a rope from the ship, and to demonstrate this a "whip" from the yard-arm was thrown out, which was made fast to the buoy by the man in it, and both were hoisted on board with great facility. In foggy weather the man can signal by the use of a shrill whistle, which is attached to the inner circle of the buoy. At night the principal light attached to the buoy is fired as it falls from the ship, the hand lights fitted inside the circle of the buoy can be fired by the man when he has got into it. The ship's crew could be easily taught or drilled in the use of the buoy when hands are piped to

HOISTING ON BOARD.

bathe. The buoy can be stowed away within less area, has more buoyancy, and is cheaper than the service buoy.—*London Graphic.*

ANNULAR WHEELS.—A NOTE FROM PROFESSOR MACCORD.

To the Editor of the Scientific American:

It has been suggested to me that a hasty or careless reader of my article on "Annular Wheels," in your SUPPLEMENT, 291, may derive an erroneous impression that teeth for inside gearing cannot be correctly laid out by the use of the odontographs in any case. In order to prevent or correct this, I beg space to state here in explicit terms (what was there distinctly implied) that those instruments may be used with perfect confidence, for laying out the teeth of annular wheels in all cases within the range of their capacity and outside the limits deduced in the article referred to.

Professor Willis's odontograph gives the centers of curvature of epicycloidal faces and flanks traced by a constant describing circle, whose diameter may be represented by 6, since the pinion of 12 teeth (the smallest for which the instrument is designed to be used) has radial flanks. Consequently it can be used for laying out an annular wheel, only when the number of teeth is at least twelve greater than the number given to the internal pinion, if the teeth are to have both faces and flanks; or six more if the teeth of either are cut down to the pitch line.

Being less familiar with the odontograph of Professor Robinson, I do not presume to be equally specific in regard to its range. But the example selected for illustration in my article is only one of many, in which the rules accompanying that instrument do not prohibit the assumption that the pinion is to have radial flanks, while the limits to which my investigations lead show that to be impossible. I would, however, add that this refers only to the rules as they now stand, and that I am confident that the inventor of this admirably ingenious implement can formulate rules adapting it for use in very many, if not all, cases of this nature. C. W. MACCORD.

Stevens Institute of Technology,
Hoboken, N. J., August, 1881.

PREVENTION OF SMOKE.

AT a recent meeting of the Society of Engineers, London, a paper was read by Mr. A. C. Engert, on the "Prevention of Smoke."

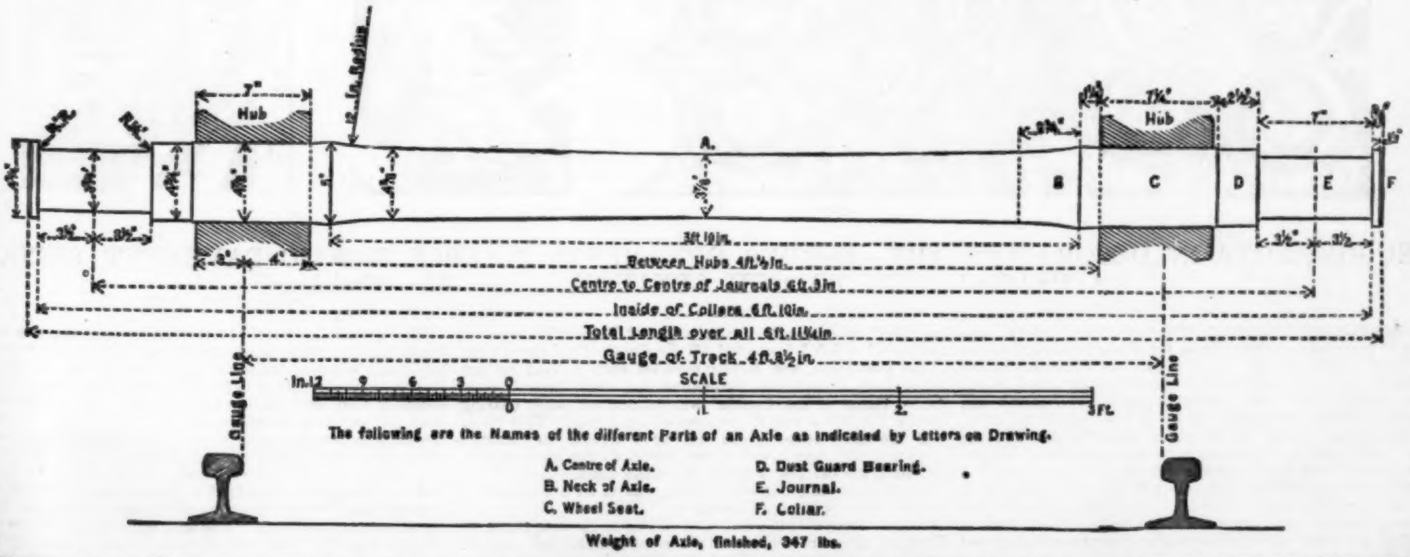
The author, in choosing the title of the "Prevention of Smoke," instead of "Consumption of Smoke," gives it as his opinion that smoke, once produced by the atmosphere, and while being carried by the air, cannot be consumed, as every particle is surrounded by a thin film of carbonic acid. When, however, smoke is condensed as soot, heat will liberate the carbon from the acid, and then the former will burn rapidly. If this theory is found to be correct, carbon cannot destroy the germs of disease floating in the air. For the consumption of smoke, many ingenious and elaborate inventions are on record, but not yet adopted on account of expense and complexity of mechanisms. A simpler apparatus is, therefore, required.

To prevent smoke, the cold air must not be allowed to come in contact with the gases arising from green coals, and, for this purpose, the furnace is, so to speak, divided into two parts. The fire door is removed from the boiler, and a box fixed on in front. On each side of this box rails are placed inside, on which a plate or shutter may rest, which may be pushed forward or backward as required. When pushed forward it passes within the boiler and drops over the firebars some eighteen inches, thereby cutting off the draught and preventing the condensation of the gases arising when fresh coals are put on, thus preventing smoke and the cooling of the boiler. A still more simple apparatus can be made with the same results, if the opening or flue will admit a higher box. The shutters can be cast together in one piece at an angle of about 130 degrees, to hang within the box on two pins or bolts, thus forming a swinging shutter. A rack is attached to the front of the shutter, to regulate the movement. The advantages of this apparatus are: the cooling of the boiler is entirely avoided, the gases are consumed so that smoke is prevented, and there is a saving of from 15 to 20 per cent. of heat and coal. In ordinary open fire grates the same object is attained, viz., the prevention of the cold air coming into contact with the green coal, by removing the fire lump, and substituting for it a cast iron box, which stands out at the back, and is open in front only, and which is to be filled with coal. Within this box is a movable iron plate, which can be forced forward, carrying with it the coals from which the gases have been extracted and consumed by the heat in front, or moved backward when the box wants refilling. To regulate the draught so that the fire burns brightly in front, a plate is fixed under the grate coming forward at the bottom. Another plate resting on pins is placed on top of the box, to prevent the flame entering the register. By this simple apparatus a bright fire is maintained in front of the grate, half of the heat usually escaping into the chimney is saved, there is little or no smoke, and the smallest coal can be used, and is, indeed, preferable. In kitcheners, stoves, and vertical boilers, a similar box to foregoing can be fixed, the movable plate being worked by a lever. This invention is also of great importance to railway companies, as it can easily be applied to locomotives. A box is placed under the foot plate, the whole width of the fire grate, and the coals put in from the top. By this means the gases are almost entirely drawn out of the coal and consumed. the result being very little, if any, smoke. To supply the grate, the coal is pushed forward by a movable plate and lever. Whether applied to furnaces, ordinary open fire grates, stoves, kitcheners, vertical boilers, or locomotives, the results of this invention, in each case, are a great saving of heat and fuel, and the reduction of smoke to a minimum.

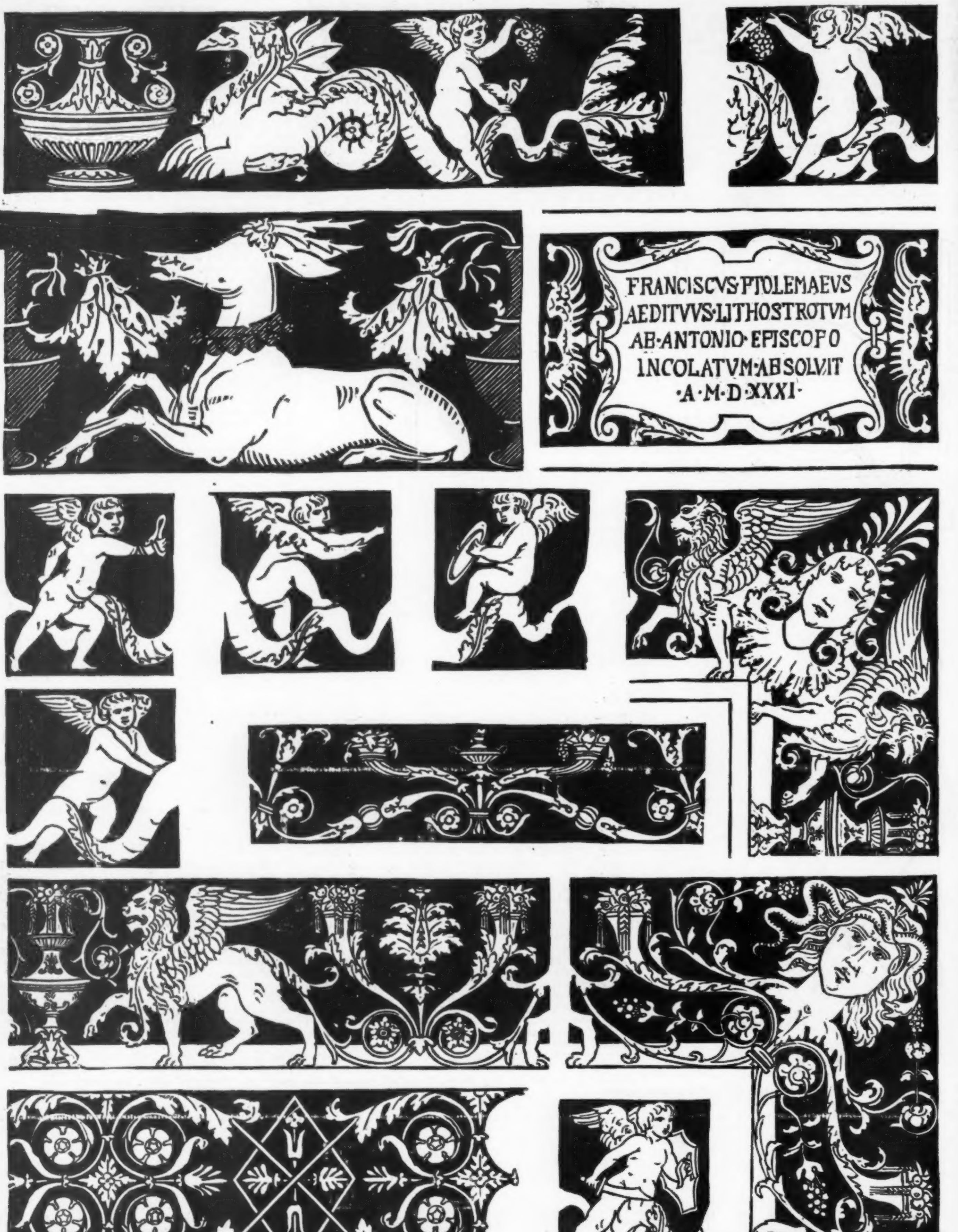
THE "WATER MARK" IN PAPER.

A RECENT number of the *Printers' Register*, of London, England, gives the following interesting information in an article condensed from a lecture on "Paper and Paper Making," by Henry Pitman.

"One feature of paper remains to be noticed—namely, the 'water-mark,' the origin of which explains some of the names by which papers are known. In the days when few persons could read, pictures and symbols were commonly used as signs or emblems of employment, such as the barber's 'pole,' the woolstapler's 'fleece,' the 'checkers,' on the tavern, and inn-signs generally. Every trade had its 'trade-mark.' The new trades of printing and paper-making naturally followed the custom by inventing emblems for different makes of paper and the title-pages of books. The marks on paper used by the early printers consisted of an ox-head and star, a dog's head and collar, a crown, a shield, a jug, etc. This last mark originated the name of 'pot' paper. The picture of a fool's head with cap and bells, gave the name of 'foolscap,' often shortened into 'cap' paper. 'post' and 'Bath post' are supposed to have originated from the mark of a posthorn. A figure of Britannia or a lion rampant supporting the cap of liberty has replaced



MASTER CAR-BUILDERS' STANDARD CAR AND TENDER AXLE.—RECOMMENDED BY THE MASTER CAR-BUILDERS' AND MASTER MECHANICS' ASSOCIATIONS AT THEIR CONVENTIONS HELD IN 1879.



SUGGESTIONS IN DECORATIVE ART.—BORDER ORNAMENTS, MARBLE MOSAIC PAVEMENT, SIENA CATHEDRAL, 14TH TO 16TH CENTURY.—*From The Workshop.*

the fool's cap and post-horn. The term 'imperial' is supposed to have been derived from the ancient name given to the finest specimens of papyri. Modern water-marks are conspicuous on the paper used in printing the *Times*, banknotes, checks, bills, and postage stamps. The marks can be seen distinctly when the paper is held up to the light. The commonest marks are the paper maker's name and the date. Ingenious water-marks have been contrived as preventives of fraud and forgeries. Bank and legal paper is sometimes treated chemically, so that any tampering with the ink can be instantly detected. The Shakespearian forgeries of Ireland, and Chatterton's pretended discoveries of old poems, would not have imposed so long upon the learned had not cunning been displayed in the use of ancient-looking paper. The mode of Ireland's deception is disclosed in his 'Confessions.' He says: 'I discovered that a jug was the prevalent water-mark of the reign of Elizabeth, in consequence of which I inspected all the sheets of old paper then in my possession, and having selected such as had the jug upon them, I produced the manuscript upon these.' Caxton's 'Game of the Chesse' was printed on paper bearing an old English letter P surmounted by a star. This book was reprinted some years ago as a tribute to Caxton's memory, and paper was made expressly for the purpose, imitating the original even to the water-mark. An old method of producing the water-mark was to fix a strong wire on the gauze of the hand-mould in the form of the object to be represented. The numbered water-marks on Bank of England notes are produced by a more complicated process. Any person who can afford so distinctive a luxury, may have paper made expressly for him, bearing his name, crest, or any device in the form of water-marks."

M. FAURE'S improved Planté battery continues to excite great interest both here and abroad. A recent attempt to give some practical indications of its capabilities in this city is very commendable The device is very simple. Two sheets of lead, after having been coated with minium or red lead, are rolled up spiral fashion, while a layer of felt is introduced to insulate each sheet, and plunged into a vessel containing dilute acid in the proportion of about 10 to 1. A current passed into this cell reduces the red lead on the one sheet or plate to metallic lead, and converts that on the other to peroxide. When the cell is discharging itself, the chemical actions are reversed. The mail advices confirm the telegraphic reports. The box of "condensed lightning" presented to Sir W. Thomson by M. Faure held, "by measurement, within the small space of one cubic foot, a power equivalent to nearly 1,000,000 of foot pounds."

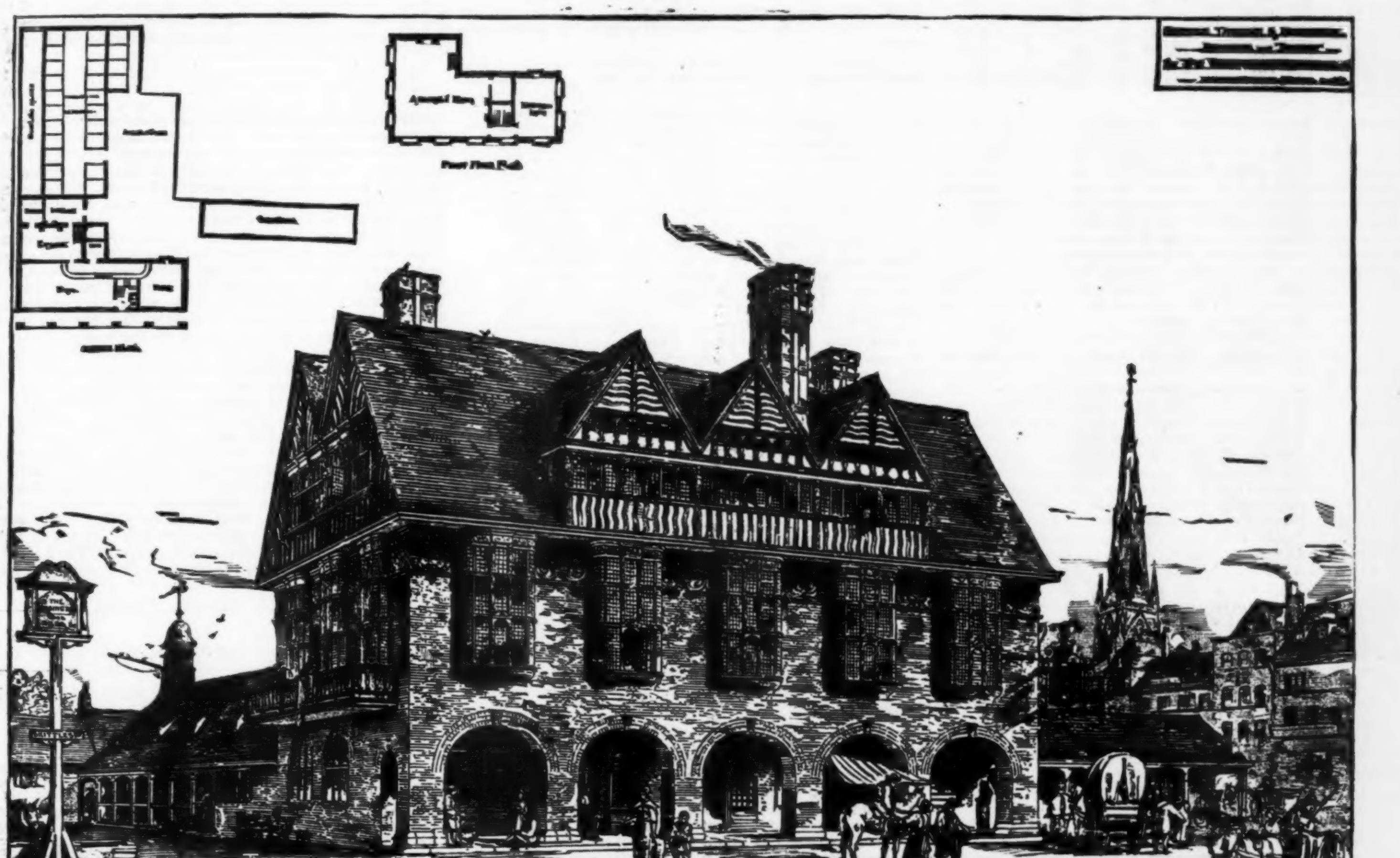
COFFEE TAVERN AND HOSTELRY, NEWARK-ON-TRENT.

THE coffee tavern and hostelry shown in our illustration is to be built and endowed by Viscountess Ossington, for the benefit of the town of Newark, and will be carried out from the designs of Messrs. Ernest George & Peto. The building is arcaded along the principal front in the manner of many old houses in Newark. The arcade will form a pleasant shelter in hot or wet weather, and tables can be placed here for those who like outdoor refreshment in the "café" manner. There is also a large garden on the river side of the tavern, overlooking the Trent, and its bridge (formerly a part of the town ramparts). This garden has an entrance from the bar, and here refreshments will be served, while music will be provided in summer evenings, after the custom of the pleasant German "Bier Garten." Along one side of this garden is an alley for American bowls. The ground floor is occupied by a large bar, adjoining which, on the same floor, are the kitchen and offices. A smaller bar, separate but served from the same counter, forms a room for boys—a feature found very necessary both for the comfort of the men and boys. There is also a small manager's parlor adjoining the bar.

A separate entrance and staircase leads to a large assembly room on the first floor, a room that will be used for concerts, lectures, and various large meetings, as well as for the farmers' ordinary on market days. On this first floor are also a reading room and a club room, for the meetings of the various friendly societies.

The second floor is formed in the spacious roof, where is provided a large billiard room for two tables. "Cubicles" or dormitories f r twelve lodgers, as well as for the rooms for the manager and servants. A bath room is provided for the use of the cubicles and lavatories, etc., conveniently for billiard room, assembly room, and the yard. There is also a ladies' cloak room.

Externally the building is treated with an arcading of red brick, and above these arches the mullioned bay-windows project. There are wide-spreading eaves and moulded cornices above, against which these bay-windows stop. Above are long mullioned windows, over which the gables are filled in with oak framing and paneling, giving a rich effect. —*Building News.*



SUGGESTIONS IN ARCHITECTURE.—AN ENGLISH TAVERN.

ON THE DISTRIBUTION OF THE ELECTRIC CURRENTS.

By M. BRILLOUIN.

THE author considers a wire connected at its ends with a system of closed conductors, or with accumulators of such a size that the intensity of the current in the whole wire can be regarded as constant in any moment. The electromotor force in the wire, E, results from the formula:

$$E = R\,i + \frac{d}{d\,t}(2\,w\,i + \Sigma\,W\,J) + \frac{d\,N}{d\,t} + V_B - V_A.$$

V_B and V_A are the variable electrostatic potentials at the end of the wire; R the resistance of the wire, w the electro dynamic potential: W the potential of the neighboring wires upon the wire. d N ($d\,t$ the work done at the unity), of the intensity in the wire of the permanent magnets from deformations of the wire and its relative changes of place.

He then considers a system of parallel wires whose ends are connected by the other unbranched wires of the circuit. He finds that the single streams do not in general follow Ohm's law. The latter comes into force only when the total energy of the intensity of the current in each wire has the same value at the end of the period as at the beginning. This is, *e. g.*, attained when the induction is elicited by the movement of magnets or currents situate outside the wires, or by a change of their intensity; or when single spirals in the branches of the currents revolve 360° round a diameter, or when all the spirals which have an inductive action upon each other revolve 180° without the action.—*Journal de Physique.*

ELECTRIC BEHAVIOR OF FLAME.

By W. HOLTZ.

THE author prefixes to his own experiments a general account of all researches on the electric behavior of flame. His own experiments refer chiefly to the changes of the form and color of flames when positively or negatively electrified. The flames are here so arranged that they form in a manner one of the electrodes of an influence machine. The positive flame becomes bluer, narrower, more pointed, while similar phenomena are scarcely perceptible in the negative flame. The latter displays, however, a curious phenomenon; its point is turned toward its own conductor. Hereby, according to the strength of the electrization and the width of the aperture of the burner, an intermittent and a constant retrogression may be distinguished. The negative flame takes the most curious shape when it issues from a large disk, or when it burns round a metal cylinder. It is then bent backward toward the metal surface, either in a curve or an angle, according to the strength of the electrization. Its point in the latter case is divided into two tufts of a peculiar shape, which on their part make movements more or less similar.

Further differences result if a conducting body is held opposite to a flame which burns as an electrode. At a considerable distance each flame bends toward it; on approaching nearer there occurs a repulsion of the negative and an attraction of the positive flame. In the latter case the attraction extends only to the upper more luminous part, not to the foot of the flame which is still repelled. Herewith is connected the circumstance that a positive flame easily passes through wire gauze, while the negative flame remains below. The pointed form of the positive flame is the cause that it readily drives a wheel with vanes, while the negative flame scarcely sets it in motion. All these and other distinctions appear especially in an unmixed gas flame, or in that of stearine, wax, or tallow, less in the flame of alcohol, and least in that of a Bunsen burner, being the less manifest the richer the flame in oxygen.

The phenomena in question are produced not merely on direct electrization, but also when the flame is exposed to the influence action of a large disk. If a flame is introduced between two smaller electric disks, it inclines to the negative side, spreading itself out. With a certain strength of current it vibrates to and fro like a pendulum, and displays a peculiar stratification. These phenomena also occur the less the richer is the flame in oxygen. It is accordingly probable that carbon and hydrogen are attracted more to the negative, but oxygen more to the positive pole, perhaps—like every distinctively polar attraction—in consequence of a certain uni-polar conductivity of the substance in question. The retrogression of the flame is thus explained: the point of the flame loses more electricity by influence than it receives by conduction. A strip of paper, one end of which is pasted to a large ball, displays similar movements as soon as the free end is pointed and made more conductive. There are two causes why the negative becomes retrograde. Either the point of the flame has here an exceptional radiating power, or the foot of the flame is here an exceptionally bad conductor. The former supposition agrees with the experiments of Wiedemann and Rühlmann, and the latter with Erman's observation on the uni-polar conduction of flames. Other grounds speak in favor of the existence of a uni-polar conduction. The resistance observed by Hittorf at the negative electrode cannot explain Erman's experiments, since if negative electricity penetrates into the flame with more difficulty, positive electricity must have more difficulty in making its exit.

Herwig's explanation of the above resistance by the assumption of a negative specific electricity does not agree with the fact that the flame is drawn exactly to the negative pole. It may otherwise be concluded that the specific electricity of flame can play no essential part in the phenomena above mentioned.—*Wiedemann's Beiblatter.*

THE PREVENTION OF STOPPAGES IN ASCENSION-PIPES.

THE last published Transactions of the Société Technique de l'Industrie du Gaz en France contain a note by M. Renaux on a plan he has introduced for preventing stoppages in ascension-pipes and in the hydraulic main. By its adoption M. Renaux claims to be able to get rid of all deposit of naphthaline, and produce gas of increased illuminating power. His plan is to evaporate upon the outer surfaces of the ascension-pipes a current of water which he causes to circulate around them. This is effected by the aid of a coil of iron wire wound round the pipes, over which about five quarts of water per hour are caused to flow. Upon the entire surface of the pipe a carbonaceous incrustation—a sort of spongy coke—is soon formed, and this assists in effecting the equal distribution of the water, which all evaporates before it reaches the top of the mouthpiece. A trial of the plan on a large scale at Toulon gave highly satisfactory results. It was found that the temperature of the pipes cooled in the way described during a six-hour charge ranged from 180° to 200° C. (356° to 392° Fahr.) at the commencement to 40° C. (104° Fahr.) at the end; the non-cooled pipes indicating temperatures ranging from 278° C. (532° Fahr.) to 81° C. (178° Fahr.) during the same period. These differences in temperature are, M. Renaux thinks, the real cause of the non-obstruction of the cooled pipes, as it is the decomposition of the tarry vapors in the non-cooled pipes which causes the deposition therein of pitch and naphthaline, and at the same time robs the gas of some of its illuminating power. In order that the distillation of coal may be carried on without these inconveniences, the temperature of the ascension pipes should be kept as much under 100° C. (212° Fahr.) as possible; and if, after leaving the hydraulic main, the gas is allowed slowly to traverse a series of pipes laid upon the retort-ovens, and kept at a temperature of about 60° C. (140° Fahr.), the tar being deposited at the end of these pipes, and the gases and vapors passing on in the ordinary way, a gas of high illuminating power, and almost entirely free from naphthaline, is obtained. At Toulon the illuminating power of the gas is stated to have increased

from 4 to 5 per cent., while naphthaline deposits almost entirely disappeared; and M. Renaux is of opinion that similar results may be obtained in other works by the adoption of his simple arrangement.

[MINING AND SCIENTIFIC PRESS.]

PHYSICAL STUDIES OF LAKE TAHOE.

By Prof. JOHN LE CONTE.

RELATION OF TEMPERATURE TO DEPTH.

BY means of a self registering thermometer (Six's) secured to the sounding line, a great number of observations were made on the temperature of the water of the lake at various depths and in different portions of the same. These experiments were executed between the 11th and 18th of August, 1873. The same general results were obtained in all parts of the lake. The following table contains an abstract of the average results, after correcting the thermometric indications by comparison with a standard thermometer:

Abstract.	Depth in feet.	Depth in Meters.	Temp. in Fahr	Temp. in Cent.
1	0—Surface	0—Surface	67°	19·44°
2	50	15·24	63°	17·22°
3	100	30·48	55°	12·78°
4	150	45·72	50°	10°
5	200	60·96	48°	8·89°
6	250	76·20	47°	8·33°
7	300	91·44	46°	7·78°
8	330*	100·58	45·5°	7·50°
9	400	120·92	45°	7·22°
10	480*	146·30	44·5°	6·94°
11	500	152·40	44°	6·67°
12	600	182·88	43°	6·11°
13	772*	235·30	41°	5°
14	1506*	459·02	39·2°	4°

* Bottom.

It will be seen from the foregoing numbers that the temperature of the water decreases with increasing depth to about 700 or 800 ft. (213 or 244 meters), and below this depth it remains sensibly the same down to 1,506 ft. (459 meters). This constant temperature, which prevails at all depths below—say 250 meters—is about 4° Cent. (39·2° Fahr.) This is precisely what might have been expected; for it is a well-established physical property of fresh water that it attains its maximum density at the above indicated temperature; in other words, a mass of fresh water at the temperature of 4° Cent. has a greater weight under a given volume (that is, a cubic unit of it is heavier at this temperature) than it has at any temperature either higher or lower. Hence, when the ice-cold water of the snow-fed streams of spring and summer reaches the lake, it naturally tends to sink as soon as its temperature rises to 4° Cent., and conversely, when winter sets in, as soon as the summer heated surface water is cooled to 4°, it tends to sink. Any further rise of temperature of the surface water during the warm season, or fall of temperature during the cold season, alike produces expansion, and thus causes it to float on the heavier water below; so that water at 4° Cent. perpetually remains at the bottom, while the varying temperature of the seasons and the penetration of the solar heat only influence a surface stratum of about 250 meters in thickness. It is evident that the continual outflow of water from its shallow outlet cannot disturb the mass of liquid occupying the deeper portion of the lake. It thus results, that the temperature of the surface stratum of such bodies of fresh water for a certain depth, fluctuates with the climate and with the seasons, but at the bottom of deep lakes it undergoes little or no change throughout the year, and approaches to that which corresponds to the maximum density of fresh water. Analogous results were obtained, nearly a century ago, from the observations of Horace Benedict De Saussure in the Swiss lakes by means of a thermometer of his own invention. The following table contains De Saussure's results (Ann. de Chim. et de Phys., second series. tome 5, page 403. Paris, 1817):

Lake.	Month.	Temp. of Surface.	Depth in Meters.	Temp. at Depth.
Geneva	August.. ..	21·20° Ct	49	6·10° Ct.
Geneva............	February ...	5·63° "	309	5·38° "
Constance	July	17·50° "	127	4·25° "
Brienz....	July	20° "	162	4·75° "
Thun......	July	18·75° "	114	5° "
Neufchatel.........	July	23·10° "	106	5° "
Lucerne	July	20° "	195	4·88° "
Bienne.....	July	20·70° "	71	6·90° "
Annecy............	May	14·38° "	53	5·63° "
Bourget	October	17·75° "	78	5·63° "
Maggiore	July	25° "	109	6·75° "

It is evident that the results of the experiments of the distinguished Swiss physicist, although executed with an imperfect thermometric instrument, in a general sense afford a striking confirmation of the deductions from my observations in relation to the distribution of temperature at different depths in the waters of Lake Tahoe.*

WHY THE WATER DOES NOT FREEZE IN WINTER.

Residents on the shores of Lake Tahoe testify that, with the exception of shallow and detached portions, the water of the lake never freezes in the coldest winters. During the winter months the temperature of the atmosphere about this lake must fall as low, probably, as 0° Fahr.[—17·78° Cent.]. According to the observations of Dr. Geo. M. Bourne the minimum temperature recorded during the winter of 1873–4 was 6° Fahr. (—14·44° Cent.) As it is evident that, during the winter season, the temperature of the air must frequently remain for days, and perhaps weeks, far below the freezing point of water, the fact that the water of the lake does not congeal has been regarded as an anomalous phenomenon. Some persons imagine that this may be due to existence of subaqueous hot springs in the bed of the lake—an opinion which may seem to be fortified by the fact that "hot springs" do occur at the northern extremity of the lake.

Lake.	Month.	Temp. of Surface.	Depth in Meters.	Temp. at Depth.
Geneva...........	September..	19·5° Ct.	33	11·6° Ct.
Geneva	September..	19·5° "	52	7·3° "
Geneva...........	September..	19·5° "	62	6·6° "
Geneva...........	September..	19·5° "	146	6·4° "
Geneva...........	September..	19·5° "	241	6·4° "
Geneva....... ...	September..	19·5° "	300	6·4° "
Thun.......	....	15·6° "	192	5·3° "
Zug	....	14·4° "	70	5° "

But there is no evidence that the temperature of any considerable body of water in the lake is sensibly increased by such springs. Even in the immediate vicinity of the "Hot springs" (which have in summer a maximum temperature of 55° Cent., or 131° Fahr.) the supply of warm water is so limited that it exercises no appreciable influence on the temperature of that portion of the lake. This is further corroborated by the fact that no local fogs hang over this or any other portion of the lake during winter, which would most certainly be the case if any considerable body of hot water found its way into the lake. The true explanation of the phenomenon may doubtless be found in the high specific heat of water, the great depth of the lake, and in the agitation of its waters by the strong winds of winter.

In relation to the influence of depth, it is sufficient to remark that, before the conditions preceding congelation can obtain, the whole mass of water, embracing a stratum of 250 meters in thickness, must be cooled down to 4° Cent., for this must occur before the vertical circulation is arrested and the cold water floats on the surface. In consequence, the great specific heat of water, to cool such a mass of the liquid through an average temperature of 8° Cent., requires a long time, and the cold weather is over before it is accomplished.

In the shallower portions the surface of the water may reach the temperature of congelation, but the agitation due to the action of strong winds soon breaks up the thin pellicle of ice, which is quickly melted by the heat generated by the mechanical action of the waves. Nevertheless, in shallow and detached portions of the lake which are sheltered from the action of winds and waves, as in "Emerald Bay," ice several inches in thickness is sometimes found. The operation of similar causes prevents the deeper Alpine lakes of Switzerland from freezing under ordinary circumstances. Occasionally, however, during exceptionally severe and prolonged winters, even the deepest of the Swiss lakes have been known to be frozen. Thus, the Lake of Geneva (maximum depth, 334 meters) was frozen in 1762 and 1805. The Lake of Constance (maximum depth, 276 meters) was frozen in 1477, 1572, 1596, 1695, and 1830. The Lake of Neufchatel (maximum depth, 135 meters) was frozen in 1573, 1656, 1795, and 1830. The Lake of Zurich has been frequently frozen, and although its maximum depth is about 195 meters, yet it is well known that this narrow and elongated body of water is very shallow over a large portion of its area—a fact which sufficiently explains its greater liability to be frozen.

WHY BODIES OF THE DROWNED DO NOT RISE.

A number of persons have been drowned in Lake Tahoe (some 14) between 1860 and 1874, and it is the uniform testimony of the residents that, in no case where the accident occurred in deep water, were the bodies ever recovered. This striking fact has caused wonder seekers to propound the most extraordinary theories to account for it. Thus, one of them says:

"The water of the lake is purity itself, but on account of the highly rarefied state of the air it is not very buoyant, and swimmers find some little fatigue, or, in other words, they are compelled to keep swimming all the time they are in the water, and objects which float easily in other water sink here like lead."

Again he says:

"Not a thing ever floats on the surface of this lake, save and except the boats which ply upon it."

It is scarcely necessary to remark that it is impossible that the diminution of atmospheric pressure due to an elevation of 6,250 ft. (1.905 meters) above the sea level could sensibly affect the density of the water. In fact, the coefficient of compressibility of this liquid is so small that the withdrawal of the above-indicated amount of pressure (about one-fifth of an atmosphere) would not lower its density more than 1-100,000th part. The truth is, that the specific gravity of the water of this lake is not lower than that of any other fresh water of equal purity and corresponding temperature. It is not less buoyant or more difficult to swim in than any other fresh water, and consequently the fact that the bodies of the drowned do not rise to the surface cannot be accounted for by ascribing marvelous properties to its waters. The distribution of temperature with depth affords a natural and satisfactory explanation of this phenomenon, and renders entirely superfluous any assumption of extraordinary lightness in the water.

The true reason why the bodies of the drowned do not rise to the surface is evidently owing to the fact that, when they sink into water which is only 4° Cent. (7 2° Fahr.) above the freezing temperature, the gases usually generated by decomposition are not produced in the intestines. In other words, at this low temperature, the bodies do not become inflated, and, therefore, do not rise to the surface. The same phenomenon would doubtless occur in any other body of fresh water under similar physical conditions.

TRANSPARENCY OF THE WATERS.

All visitors to this beautiful lake are struck with the extraordinary transparency of the water. At a depth of 15 or 20 meters (49 2 or 65·62 ft.) every object on the bottom, on a calm sunny day, is seen with the greatest distinctness. On the 6th of September, 1873, the writer executed a series of experiments, with the view of testing the transparency of the water. A number of other experiments were made, August 28 and 29, under less favorable conditions. By securing a white object of considerable size—a horizontally-adjusted dinner-plate about 9·5 inches in diameter—to the sounding-line, it was ascertained that (at noon) it was plainly visible at a vertical depth of 33 meters, or 108·27 English ft. It must be recollected that the light reaching the eye from such submerged objects must have traversed a thickness of water equal to at least twice the measured depth. In the above case it must have been at least 66 meters, or 216·54 ft. Furthermore, when it is considered that the amount of light regularly reflected from such a surface as that of a dinner-plate, under large angles of incidence in relation to the surface, is known to be a very small fraction of the incident beam (probably not to exceed 3 per cent. or 4 per cent.), it is evident that solar light must penetrate to vastly greater depths in these pellucid waters.*

Moreover, it is quite certain that if the experiments, in relation to the depths corresponding to the limit of visibility of the submerged white disk, had been executed in the winter instead of summer, much larger numbers would have been obtained. For it is now well ascertained, by means of the researches of Dr. F. A. Forel, of Lausanne, that the waters of the Alpine lakes are decidedly more transparent in winter than in summer. Indeed, it is reasonable that when the affluents of such lakes are locked in the icy fetters of winter, much less suspended matter is carried into them than in summer, when all the sub-glacial streams are in active operation.

The experimental investigations of

PROF. F. A. FOREL

on the "Variations in the Transparency of the Waters" of the Lake of Geneva (Archives des Sci. Phys. et Nat., Tome 59, p. 137, *et seq.*, Juin, 1877), show that the water of this famous Swiss lake is far inferior in transparency to that of Lake Tahoe. Prof. Forel employed two methods of testing the transparency of the waters of Lake Geneva at different seasons of the year.

1st. The direct method, by letting down a white disk 25 centimeters (about the size of the dinner-plate used by me), attached to a sounding-line, and finding the depths corresponding to the limit of visibility. For the seven winter months, from October to April, he found, from 46 experiments in 1874–75, a mean of 12·7 meters, or 41·67 English ft.; and for the five summer months, from May to September, he found during the same year, a mean of 6·6 meters, or 21·65 ft. The maximum depth of the limit of visibility, observed by him, was 17 meters, or 55·88 English ft.; being a little more than half the depth found by me in Lake Tahoe, early in the month of September.

2d. The other method employed by Prof. Forel was the indirect or photographic method. This consisted in finding the limiting depth at which solar light ceased to act on paper rendered sensitive by means of chloride of silver. If we assume that the same laws which regulate the penetration of the actinic rays of the sun are applicable to the luminous rays, this method furnishes a much more delicate means of testing the transparency of water, and especially of determining how deep the direct solar rays penetrate. Forel found the limit of obscurity for the chloride of silver paper, in winter, to be about 100 meters, and in summer, about 45 meters; numbers (as we should expect) far exceeding those furnished by the limit of visibility of submerged white disks. Assuming that the index of transparency of the water of Lake Tahoe to be in winter no greater than twice that of Lake Geneva, it follows that, during the cold season, the solar light must penetrate the waters of the former to a depth of at least 200 meters. From his admirable photometrical investigations Bouguer estimated (Traité d'Optique sur la Gradation de la Lumiere, La Caille's Ed., Paris, 1760) that in the purest sea water, at the depth of 311 Paris ft., or 101 meters, the light of the sun would be equal only to that of the full moon, and it would be perfectly opaque at the thickness of 679 Paris ft., or 220·57 meters. In relation to the comparative transparency of different waters, we may be permitted to cite a few results obtained by the method of depths corresponding to the limit of visibility of white disks. Even absolutely pure water is not perfectly transparent; it absorbs a certain amount of light, so that at a determinate depth it is opaque. The following table presents us comparative results which may be of some interest:

Water.	Season.	Depth of visibility in meters.		Observer.
Lake of Geneva .	Summer	5·30	Min'm.	F. A. Forel
" " ..	"	8·20	Max.	" "
" " ..	"	6·60	Mean.	" "
" " ..	Winter	10·20	Min'm.	" "
" " ..	"	17·00	Max.	" "
" " ..	"	12·70	Mean.	" "
Lake Tahoe. ...	Summer	33·00	Max.	Nobis
Pacific O Wallis I.	"	40·00	....	Capt. Berard
Mediterr'n nr. Civita Vecchia	"	42·50	....	P. A. Secchi
Atlantic O	"	49.50	....	L. F. de Pourtales†

Inasmuch as our observations on the water of Lake Tahoe were made during the latter portion of August and the beginning of September, it seems probable, from Forel's results in Lake Geneva, that winter experiments would place the limit of visibility as deep, if not deeper than Pourtales found in the Atlantic ocean. It may be proper to add that Prof. Forel does not ascribe the variations in the transparency of water of the Swiss lake with the season exclusively to the greater or less abundance of suspended matter; but also to the fact, which seems to be confirmed by the experiments of H. Wild, that increase of temperature augments the absorbing power of water for light:

Place.	State of Weather.	Date of Obs.	Limit of Visibility.
Offak.......	Calm and cloudy.	Sept. 13.	18 meters.
Offak.......	Calm and clear.	Sept. 14.	23 meters.
Pt. Jackson..	Clear.	Feb. 12 and 13.	12 meters.
Ascension I..	Favorable.	Jan. (11 exp'ts).	9 to 12 meters.

Vide Œuvres Completes de "Francois Arago," 2d ed., Tome 9, p. 209. Paris, 1865.

It is evident that this cause is more efficient in summer than in winter:—superior transparency of waters in pools in limestone districts. But the transparency of the

* Similar confirmatory results were obtained by Sir H. T. De la Beche, in 1819-20, by means of a self-registering minimum thermometer. Thus he found (Ann. de Chim. et de Phys., Second Series, tome 19, page 77 *et seqq.* Paris, 1821).

* According to the experiments of Bouguer, out of 1,000 rays of light incident upon polished black marble, the following were the proportional numbers reflected at the several angles measured from the surface of the marble.

At an angle of	3° 35′	600	were reflected.
" "	15°	156	"
" "	30°	51	"
" "	80°	23	"

—*Traite d'Optique*, p. 125.

† So few exact observations have been made on the transparency of sea-water, that it may be proper to add the following results obtained by Capt. Duperrey during the "Voyage de la Coquille." The apparatus employed consisted of a circular board 66 centimeters in diameter, painted white, to which a weight was attached, and so adjusted that when let down by a line the white disk descended horizontally in the water.

waters occupying the pools in certain limestone districts, unquestionably far surpasses that of any of the Alpine lakes or any of the inter-tropical seas. The observations and experiments executed by the writer during his investigations—in the month of Dec., 1859—in relation to the "Optical Phenomena Presented by the Silver Spring," in the State of Florida (vide Proc Am. Assoc. Adv. of Sci., vol. 14, p. 38–46; Aug., 1860. Also Am. Jour. Sci., 2d series, vol. 31, p. 1–12; Jan., 1861), indicated a degree of transparency in the water surpassing anything which can be imagined. The depth of this remarkable pool varied, in different portions, from 30 to 36 English ft., or from 9·14 to 10·97 meters; yet "every feature and configuration of the bottom of this gigantic basin was almost as distinctly visible as if the water was removed and the atmosphere substituted in its place. The sunlight illuminated the sides and bottom of this remarkable pool nearly as brilliantly as if nothing obstructed the light. The shadows of our little boat of our overhanging heads and hats, of projecting crags and logs, of the surrounding forests, and of the vegetation at the bottom, were distinctly and sharply defined." The experiments in relation to vertical depth at which printed cards could be read, when viewed vertically, afforded a good illustration of the extraordinary transparency of these waters. Comparative experiments in relation to the distances at which the same cards could be read in the air, showed that when the letters were of considerable size, say 6 or 7 millimeters or more in length, on a clear and calm day they could be read at about as great a vertical distance beneath the surface of the water as they could be in the atmosphere. But it would be a grave error to imagine that these results indicate that sunlight undergoes no greater diminution in traversing a given thickness of this water than in passing through an equal stratum of air. For, in both cases, when the cards are strongly illuminated, the reading distance is limited by the smallness of the images of the letters on the retina, and not by the amount of light reaching the eye. Nevertheless, these experiments prove conclusively that, at the depth of 10 meters, the illumination was sufficiently intense to secure this limiting condition, and thus serve to convey a more distinct idea of the wonderful diaphanous properties of these waters than any verbal description. The experiments were executed about noon at the winter solstice (lat. 29° 15' north), and were made on various-sized letters, and at depths varying from 2 to 10 meters. It would be exceedingly interesting to test the transparency of the waters of similar springs in the limestone districts by the limit of visibility of white disks, when the depth is sufficiently great to admit of the application of this method. The famous fountain, situated about 10 or 15 miles south of Tallahassee, in the State of Florida, called Wakulla Spring, is represented to be deeper than the Silver Spring, and to be equally transparent. But we have, as yet, no trustworthy measurements, or observations in relation to the comparative diaphanous properties of the waters of other limestone pools.*

CAUSE OF SUPERIOR TRANSPARENCY.

It only remains to indicate the causes which produce the extraordinary transparency of the waters occupying the Silver Spring. It may be remarked that these diaphanous properties are perennial. They are not in the slightest degree impaired by season, by rain, or drought.

The comparatively slight fluctuations in the level of the water of the pool produced by the advent of the rainy season, are not accompanied by any turbidity of its waters. At first sight it may seem paradoxical that in a country where semi-tropical rains occur, the waters of this spring should not be rendered turbid by surface drainage. But the whole mystery vanishes when we consider the peculiar character of the drainage of this portion of Florida.

Although the surface of the country is quite undulating or rolling, the summits of many of the hills being 30 or 40 ft. above the adjacent depressions, yet there is no surface drainage. There is not a brook or rivulet to be found in this part of the State. The whole drainage is subterranean; even the rain-water, which falls near the banks of the pool and bold stream constituting its outlet, passes out by underground channels. There is not the slightest doubt but that all of the rain-water which falls on a large hydrographic basin, passes down by subterraneous channels and boils up and finds an outlet by means of the Silver Spring and the smaller tributary springs which occur in the coves along the margin of its short discharging stream. The whole surface of the country in the vicinity, and probably over the area of a circle of 10 or 15 miles radius, whose center is the Silver Spring, is thickly dotted with lime sinks, which are the points at which the surface-water finds its entrance to the subterranean passages. New sinks are constantly occurring at the present time. The beautiful minia ure lakes whose crystal waters are so justly admired, which occur in this portion of Florida, are doubtless nothing more than limesinks of ancient date. Under this aspect of the subject it is obvious that all the rainfall on this hydrographic basin boils up in the Silver Spring, after having been strained, filtered, and decolorized in its passage through beds of sand, tortuous underground channels. It thus comes out, not only entirely free from all mechanically-suspended materials, but completely destitute of every trace of organic coloring matter. For this reason there is a striking contrast between the color and transparency of the waters of the Silver Spring stream and those of the Ochlawaha River at their junction, the latter draining a country whose drainage is not entirely subterraneous.

The above-mentioned conditions seem to be fully adequate to persistently secure the waters of this spring from the admixture of insoluble and suspended materials, as well as from the discoloration of organic matters in solution. But, inasmuch as these waters appear to be more diaphanous than absolutely pure water, it is possible that the minute quantity of lime which they hold in solution may exercise some influence in augmenting their transparency. There is nothing *a priori* improbable in the idea that the optical, as well as the other physical properties of the liquid, may be altered by the materials held in solution. This is an interesting physico-chemical question, which demands experimental investigation.

COLOR OF THE WATER OF LAKE TAHOE.

One of the most striking features of this charming mountain lake is the beautiful hues presented by its pellucid waters. On a calm, clear, sunny day, wherever the depth is not less than from 50 to 60 meters, to an observer floating above its surface, the water assumes various shades of blue; from a brilliant cyan blue (greenish blue) to the most magnificent ultramarine blue, or deep indigo blue. The shades of blue increasing in darkness in the order of the colors of the solar spectrum, are as follows: Cyan blue (greenish blue), prussian blue, cobalt blue, genuine ultramarine blue, and artificial ultramarine blue (violet blue).

While traversing one portion of the lake in a steamer, a lady endowed with a remarkable natural appreciation and discrimination of shades of color declared that the exact tint of the water at this point was "Marie Louise blue." The waters of this lake exhibit the most brilliant blueness in the deep portions, which are remote from the fouling influences of the sediment-bearing affluents and the washings of the shores. On a bright and calm day, when viewed in the distance, it had the ultramarine blue; but when looked fair down upon it was of almost inky blackness—a solid dark blue, qualified by a trace of purple or violet.

Under these favorable conditions, the appearance presented was not unlike that of the liquid in a natural dyeing vat. A clouded state of the sky, as was to be expected, produced the well-known effects due to the diminished intensity of light, the shades of blue became darker, and in extreme cases, almost black blue. According to our observations, the obscurations of the sky by the interposition of clouds produced no other modifications of tints than those due to a diminution of luminosity.

In places where the depth is comparatively small and the bottom is visibly white, the waters assume various shades of green, from a delicate apple green to the most exquisite emerald green. Near the southern and western shores of the lake, the white sandy bottom brings out the green tints very strikingly. In the charming *cul de sac* called "Emerald Bay," it is remarkably conspicuous and exquisitely beautiful. In places where the stratum of water covering white portions of the bottom is only a few meters in thickness the green hue is not perceptible, unless viewed from such a distance that the rays of light emitted obliquely from the white surface have traversed a considerable thickness of the liquid before reaching the eye of the observer. The experiments with the submerged white dinner plate in testing the transparency of the water, incidentally manifested, to some extent, the influence of depth on the color of the water. The white disk presented a bluish green tint at the depth of from 9 to 12 meters; at about 15 meters it assumed a greenish blue hue, and the blue element increased in distinctness with the augmenting depth, until the disk became invisible or undistinguishable in surrounding mass of blue waters. The water intervening between the white disk and the observer did not present the brilliant and vivid green tint which characterized that which is seen in the shallow portions of the lake, where the bottom is white. But this is not surprising when we consider the small amount of diffused light which can reach the eye from so limited a surface of diffusion.

In studying the chromatic tints of these waters, a hollow pasteboard cylinder, 5 or 6 centimeters in diameter and 60 or 70 centimeters in length, was sometimes employed for the purpose of excluding the surface reflection and the disturbances due to the small ripples on the water. When quietly floating in a small row boat, one end of this exploring tube was plunged under the water, and the eye of the observer at the other extremity received the rays of light emanating from the deeper portions of the liquid. The light thus reaching the eye presented essentially the same variety of tints in the various portions of the lake as those which have been previously indicated. Hence it appears that, under various conditions, such as depth, purity, state of sky, and color of bottom, the waters of this lake manifest nearly all the chromatic tints presented in the solar spectrum between greenish yellow and the darkest ultramarine blue, bordering upon black blue. It is well known that the waters of oceans and seas exhibit similar gradations of chromatic hues in certain regions. Navigators have been struck with the variety and richness of the tints presented in certain portions by the waters of the Mediterranean Sea, the Atlantic and Pacific Oceans, and especially those of the Caribbean Sea. In some regions of the oceans and seas, the green hues, and particularly those tinged with yellow, are observed in comparatively deep water, or at least where the depths are sufficiently great to prevent the bottom from being visible. But this phenomenon seems to require the presence of a considerable amount of suspended matter in the water. In no portion of Lake Tahoe did I observe any of the green tints, except where the light-colored bottom was visible. This was probably owing to the circumstance that no considerable quantity of suspended material existed in any of the waters observed.

PHYSICAL CAUSE OF THE COLOR OF THE WATERS OF CERTAIN LAKES AND SEAS.

The study of the beautiful colors presented by the waters of certain lakes and seas has exercised the sagacity of a great number of navigators and scientists, without resulting in a perfectly satisfactory solution of the problem. And, although recent investigations seem to furnish a key to the true explanations, yet the real cause of the phenomena appears to be very imperfectly understood, even among physicists.

For example, some persons persist in assigning an important function to the blue of the sky in the production of the blue color of the water. Thus, as late as 1870, Dr. Aug. A. Hayes, in an article on "The Cause of the Color of the Waters of Lake Geneva," (*Am. J. Sci.*, 2d series, vol. 49 p. 186 *et seq*—1870), having satisfied himself by chemical analysis that no coloring matter existed in solution, distinctly ascribes the blue color of the water to the reflection and refraction of an azure sky in a colorless water. He insists that the water of this lake "responded in unequal coloration to the state of the sky, as if the water mirrored the sky under this condition of beauty."

The question here presented is highly important in discussing the cause of the blue color of the deep waters. For the first preliminary point to be established, is whether the colored light comes from the interior of the mass of water, or whether it is nothing more than the azure tint of the sky, reflected from the surface of the liquid. In other terms, whether the water is really a colored body, or only mirrors the color of the sky. If the water merely performs the functions of a mirror, the explanation of the blue color of such waters is so simple and obvious that it is astonishing how it comes to pass that physicists have been so long perplexed in relation to the solution of this problem. This idea is susceptible of being subjected to decisive tests. It seems to me that the phenomena cannot be due to mirror-like reflections of the azure sky for the following reasons: (*a*) If the blue color of the water is produced by the reflection of an azure sky all tranquil waters should present this tint under an equally vivid blue sky. It is well known that this deduction is not confirmed by observation. (*b*) In looking vertically down into the blue waters—a condition rendering surface reflection very small—it is obvious that the tints emanate from the interior of the liquid. (*c*) When the sky is clear and the surface of the water is tranquil, the azure tint frequently far surpasses in vividness that of the sky itself. This would of course be impossible if the color was nothing more than the reflected image of the azure sky; since the reflected image must be less brilliant than the object. (*d*) A clouded state of the sky does not, under ordinary circumstances, prevent the recognition of the blue tint of the waters, although of course it is of less intensity. This fact is attested by a number of observers in relation to the blue waters of both lakes and seas; and it is evidently inconsistent with the idea of a mirror like reflection of an azure sky. (*e*) Tranquil waters sometimes reflect the warm colors of the horizon, reflecting all the tints of a luminous sky so exactly that sky and water appear to be blended with each other. Under these conditions the blue tints from the interior of the liquid are overpowered by the more brilliant surface reflections; for, if a gentle breeze ruffles the surface with capillary waves, the bright surface tints vanish, and the blue from the interior immediately predominates.* (*f*) My experiments with the "pasteboard exploring tube," seem to prove beyond question that the color-rays proceed from the depths of the water and not from its surface; for in this case superficial reflection was eliminated. (*g*) Finally, the character of the polarization impressed upon the blue light emanating from the azure waters of the Lake of Geneva (first announced by J. L. Soret, in the spring of 1869, and subsequently confirmed by other observers), affords a satisfactory demonstration that the blue rays are not reflected from the surface, but, on the contrary, are veritable luminous emanations from the interior of the liquid.

This point will hereafter receive special consideration in connection with the cause of the blue color. The foregoing reasons appear to be abundantly sufficient to establish the fact that in the blue waters of lakes and seas the color rays do actually come from the interior of the mass of liquid. Moreover the experiments of Soret and Tyndall prove that when a beam of light, thrown into an obscured chamber, is concentrated by a lens and made to pass through small masses of the blue waters taken from a number of Swiss lakes, as well as from the Mediterranean Sea, the luminous cone which traversed the liquid was in all cases distinctly blue. These experimental results are absolutely demonstrative of the fact that the diffused blue light proceeds from the interior of the transparent liquid. (Soret, in "Archives des Sci, Phys. et Nat," tome 39, p. 357—December, 1870. Tyndall, in *Nature*, vol. 2. p. 489—October 20 1870.)

COLORS OF TRANSPARENT LIQUIDS.

So far as known, the colors of transparent liquids are due to the modifications of white light produced in the interior of the substances traversed by the luminous rays. Besides the well-known chromatic phenomena arising from the refraction and dispersion of light (which are out of the question in relation to the subject under consideration), there are, in this class of bodies, three recognized causes of coloration, viz.: 1st, Selective absorption of transmitted light; by which, through the extinguishing of certain rays, the emergent light is colored. 2d, Selective reflection of light from the interior of the liquid; by which, both the transmitted and reflected rays are colored. 3d, Fluorescence, by which colors are manifested by a sort of selective secondary radiation, in which light waves of greater length than those of the exciting rays are emitted from the interior of the liquid. Although the admirable researches of G. G. Stokes, Edmond Becquerel, Alex. Lallemand, Hagenbach, and others, on the "Illumination of Transparent Liquids," proves that a greater number of such bodies possess the property of fluorescence than was formerly supposed, yet all investigators concur in classifying pure water among the non-fluorescent liquids. Hence in the case of this liquid, in a state of purity, the admitted causes of coloration are reduced to two, viz.: Selective absorption and selective reflection in the interior of the transparent mass.

If the liquid traversed by the light is so constituted that none of the rays are reflected from its interior parts, while selective absorption is active, then the transmitted light is alone colored, according to the rays that may be extinguished by absorption. On the other hand, in transparent liquids in which there is no absorption of light, both the transmitted and the reflected light may be colored by selective reflection. For, it is evident, that if some of the rays are selectively reflected in the interior of the transparent mass, the transmitted light and the reflected light must present different colors. It is, likewise, obvious, that if all of the white light entering the transparent medium is thus disposed of, the transmitted light and the reflected light must present tints which are exactly complementary. In most cases, however, when selective reflection occurs, there will generally be some selective absorption; consequently the color by transmission will not always be exactly complementary to the color by reflection. In fact, this exact complementary relation cannot be realized when any portion of the light is absorbed. Moreover, in many cases in which there is a rapid absorption of particular rays, the transmitted and reflected lights are of the same color. For example, there are large classes of bodies (such as solutions of indigo, sulphate of copper, etc., and also various colored glasses), which are of the same color by reflection and transmission. In such cases, the rays of all the other colors are speedily extinguished by absorption, while a portion of the incident characteristic color-rays are reflected, and the rest are transmitted. Thus, in many blue colored solutions, not only is the transmitted light blue, but the blue tint is visible in all directions by means of the diffused light. *Opalescent Aqueous Media.*—It is now well established that finely divided substances suspended in water impart to it the property of diffused selective reflection, whereby certain chromatic phenomena are produced. It has been long recognized that if about one part of milk be added to 50 parts of distilled water, the presence of the diffused milk globules in the midst of the liquid imparts to it a bluish tint by the scattered reflected light, while the transmitted light acquires a yellowish color. Similar phenomena are observed when delicate precipitates of magnesia, or of amorphous sulphur, are diffused in pure water;

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* There are numerous lakes in the Scandinavian peninsula, whose waters are said to be very transparent, objects in the bottom being visible at depths of from 30 to 37 meters; more specifically, in Lake Wetter in Sweden, a farthing is said to be visible at a depth of 20 fathoms, or 36·575 meters. But such vague popular estimates are scarcely worthy of consideration. Still less trustworthy are the unverified accounts we have, that in some parts of the Arctic ocean shells are distinctly seen at the depth of 80 fathoms; and that among the West India Islands, in 80 fathoms of water, the bed of the sea is as distinctly visible as if seen in air. (Somerville's Phys Geog., Am. Ed., 1858, p. 199.) Perhaps it should have been put feet instead of fathoms.

* Indeed, in many cases this surface reflection seriously interferes with the vivid perception of the blue tints from the interior. The beautiful blue light which illuminates the interior of the famous "azure grotto" on the shores of the Island of Capri, in the Bay of Naples, is of great splendor, because its waters, while receiving a full supply of the transmitted solar beams through the large subaqueous entrance, are protected from the surface reflection by the smallness of the opening above the water level.

and, likewise, when weak alcoholic solutions of certain essential oils are mingled with this liquid.

The admirable experiments of Ernst Brucke, in 1852 (Pogg. Ann., vol. 88, p. 363–385), prove that mastic and other resins, which are soluble in alcohol, will be precipitated in a finely divided state when added to water; and that when such a precipitate is sufficiently diluted, it gives the liquid a soft, sky-like hue by the diffuse reflected light, while the transmitted light is either yellow or red, according to the thickness of the stratum traversed. These results have been abundantly verified by more recent experiments, and notably by those of Tyndall (probably about 1857), and by those of the writer during the years 1878 and 1879. The suspended particles of resin are so extremely attenuated, that they remain mingled with the water for months, without sensibly subsiding. In many instances, they are so fine as to escape detection by the most powerful microscopes—they are ultra-microscopic in smallness. Media which possess the property of decomposing compound white light by selective reflection, have been characterized as opalescent. The distinguishing characteristics of opalescent liquids are: 1st, that the reflected and transmitted lights are different in color; and 2d, that the tints of the two colors are more or less complementary. It is evident, however, that when the liquid exercises any selective absorptive action on light, the tints of both the reflected and transmitted lights will be more or less modified, according to the character of the rays which are withdrawn by absorption. Hence it follows that the tints by diffuse reflection and by transmission may deviate more or less from the exact complementary relation.

COLOR OF PURE WATER.

In the investigation of the "Causes of the colors of the waters of certain lakes and seas," it is manifestly of primary importance to determine the color of pure water; for, if it is inherently colored, the tints afforded by impurities must be modified by the admixture of the hues proceeding from the liquid itself. Although pure water in small masses appears to be perfectly colorless, yet most physicists have been disposed to admit an intrinsically blue color as belonging to absolutely pure water, when viewed in sufficiently large masses. Thus, Sir I. Newton, Mariotte, Euler, Sir H. Davy, Count de Maistre, Arago, and others, ascribe the azure tints of the deep waters of certain lakes and seas to the selective reflection of the blue rays from the molecules of the liquid itself; while the green and other tints exhibited by other waters are due to the impurities or to various modifications and admixtures of reflected light from suspended materials and from the bottom.

More recent investigations seem to furnish some clew to the solution of this problem. R. W. Bunsen, in 1847, was the first to test the color of pure water by direct experiment (Ann. der Chem. und Pharm., vol. 62, pp. 44–45, 1847). He provided himself with a glass tube 5·2 centimeters in diameter and 2 meters long, which was blackened internally with lampblack and up to within 1·3 centimeters of the end, which was closed by a cork. The tube being filled with chemically pure water, and pieces of white porcelain being thrown into it, it was placed in a vertical position on a white plate.

On looking down through the column of water at the bits of porcelain at the bottom which were illuminated by the white light reflected from the plate through the rim of clear uncoated glass at the lower extremity, he observed that they exhibited a pure blue tint, the intensity of which diminished as the column of water was shortened. The blue coloration was also recognized when a white object was illuminated through the column of water by direct sunlight, and viewed at the bottom of the tube through a small lateral opening in the black coating. It is evident that the blue tints manifested in these experiments were those of the transmitted light, and they indicate that pure distilled water absorbs the luminous rays constituting the red end of the spectrum more copiously than those of the blue extremity. But they do not touch the question of the color of the diffused light reflected from the interior of the mass of water itself. About 1857, John Tyndall confirmed the results of Bunsen's experiments in the following manner:

"A tin tube, 15 feet long and 3 inches in diameter, had its ends stopped securely by pieces of colorless plate glass. It is placed in a horizontal position, and pure water is poured into it through a small lateral pipe until the liquid reaches half way up the glasses at the end; the tube then holds a semi-cylinder of water and a semi-cylinder of air. A white plate or a sheet of white paper, well illuminated, is then placed a little distant from the end of the tube, and is looked at through the tube. Two semicircular spaces are seen, one by the light which has passed through the air, and the other by the light which has passed through the water. It is always found that, while the former semicircle remains white, the latter is vividly colored."

Prof. Tyndall was never able to obtain a pure blue, the nearest approach to it being a blue-green. When the beam from an electric lamp was sent through this tube, the transmitted image projected upon a screen was found to be blue-green when distilled water was used ("Glaciers of the Alps," part 2d, 6; "Color of Water and Ice," Am. ed., p. 254–255, Boston, 1861). It will be noticed that Prof. Tyndall makes no allusion to the color of the diffused or scattered light; indeed, his tin tube rendered it impossible for him to observe it. It is evident that, at this time (1857), this sagacious physicist was disposed to ascribe the blue tints observed in purest natural waters, exclusively to their absorbent action on the transmitted light. Thus, extending the analogy of the action of water on dark heat, to the luminous rays of the solar spectrum, he says:

"Water absorbs all the extra red rays of the sun, and if the layer be thick enough, it invades the red rays themselves. Thus, the greater the distance the solar beams travel through pure water, the more they are deprived of those components which lie at the red end of the spectrum. The consequence is, that the light finally transmitted by water, and which gives it its color, is blue" (op. cit. supra, p. 254).

According to this view, it would seem that pure water is really colored in the same sense as a weak solution of indigo—that is, it is blue both by reflected and transmitted light.

In December, 1861, W. Beetz, of Erlangen, obtained results analogous to those of Professors Bunsen and Tyndall, by the somewhat imperfect method of looking through considerable thickness of distilled water at the transmitted light made to pass, by repeated reflections, across a box ten inches long filled with this liquid. The transmitted light ultimately became dark blue, "with a very feeble tinge of green" (Pogg. Ann., vol. 115, pp. 137–147, Jan., 1862; also Phil. Mag., 4th series, vol. 24, pp. 218–224, Sept., 1862). My own experiments, executed on various occasions in 1878–1879, afford complete verification of the results obtained by the preceding physicists.

My arrangements were similar to those of Prof. Tyndall, except that a series of three glass tubes—of about three centimeters in clear internal diameter, connected by India-rubber tubing, and having an aggregate length of about five meters—was employed instead of the tin tube used by him. Moreover, instead of the electric beam, I employed solar light thrown into a large, darkened lecture room, by means of a "porte lumière;" the small beam passing through the first diaphragm at the window, being rendered nearly uniform in diameter by the interposition of a secondary screen, with a small aperture in it, just before the light entered the end of the horizontally adjusted series of tubes.

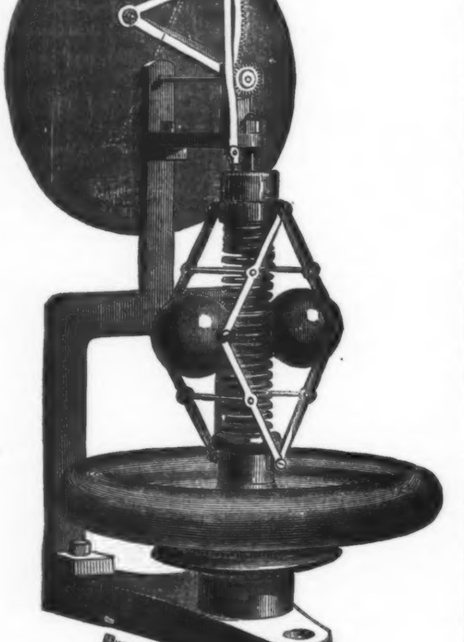
By this arrangement an approximate mathematical ray was obtained, which secured the transmission of the light along the axis of the column of water, without the possibility of the emergent beam being mixed with any light reflected from the internal surface of the glass tube. In every instance in which distilled water was used, the tint of the image of the emergent beam received upon a white screen was either greenish-blue or yellowish-green; the former tint seemed to characterize the summer, and the latter hue the winter experiments.

Like Prof. Tyndall, I failed to obtain a pure blue color in the transmitted light, the nearest approach to it being greenish-blue. Hence, it appears that, in a general way, my experiments confirm the opinion that pure water absorbs to a somewhat greater extent the solar rays constituting the red end of the spectrum; while, at the same time, they seem to indicate—in accordance with the deductions of Wild—that the absorption is more active at elevated temperatures. It must be borne in mind that these results relate to the tints of the transmitted light.

(To be continued.)

THE STROPHOMETER.

Hearson's "Strophometer," or speed indicator, is designed to show at a first glance, by the position of a needle on a graduated disk, the number of revolutions that are being made by an engine. The apparatus, as shown in the accompanying figure, is represented without its box or case. It is to be connected with the engine whose speed it is desired to know, by means of a catgut cord passing around the channel of a pulley placed beneath.



THE STROPHOMETER.

The disk is graduated, and gearings having a proper ratio with the different speeds of the engine are fixed to the apparatus—the maximum velocity of the strophometer being 500 revolutions per minute.

For example, if the apparatus is connected with an engine whose maximum velocity is 100 revolutions per minute, gearings are used which have a ratio of 1:5. For marine engines having shafts of large diameter on which it would be inconvenient to place a pulley, a wooden drum is used, which is kept in contact with the coupling sleeve of the shaft by means of a cord, and the catgut cord which puts the strophometer in motion passes around this drum. The latter is so arranged that it can be easily detached from the coupling sleeve.

Stationary engines of a slow motion, whose speed varies from thirty to fifty revolutions per minute, require a supplementary division of the disk into twenty parts, which may themselves be again divided so as to give a very accurate indication.

This apparatus is equally applicable to locomotives. When so used the catgut cord passes over a small pulley placed over the axles of the driving wheels. The disk is then graduated so as to show the number of miles made per hour; and the diameter of the pulley depends then upon that of the driving wheels.

Mr. C. S. Read recently said before the London Farmers' Club: "American agriculturists get up earlier, are better educated, breed their stock more scientifically, use more machinery, and generally bring more brains to bear upon their work than the English farmer. The practical conclusion is, that if farmers in England worked hard, lived frugally, were clad as meanly as those of the States, were content to drink filthy tea three times a day, read more and hunted less, the majority of them may continue to live in the old country."—*N. E. Farmer.*

RADIO-DYNAMICS.

By Pliny Earle Chase, LL.D.*

Your committee have invited me to lecture upon some of the results of investigations in which I have been specially engaged. My subject is given, in one part of the announcement, as astronomy; in another, as the music of the spheres. The former title is so far appropriate, as it designates the source from which the greater part of my discoveries have been derived; the latter, as indicating the universal harmonies which are manifested, both by atoms and by stars, by microscopic and macrocosmic spheres alike, and which are, as I shall try to show you, the necessary results of the plan which has established the stability of the physical universe.

It will be impossible, in two lectures, to do more than glance at a few of the instances of prevailing rhythm, but I think you will find those which I have time to bring before you quite sufficient to serve as the solid groundwork of a science which is both the oldest and the newest of all sciences—the science of photo dynamics or radio-dynamics. I call it the oldest, because we are told in Genesis that the first act of the Creator, in educing order out of chaos, was the command, "Let there be light;" the newest, because its right to recognition is as yet but sparingly and somewhat hesitatingly accepted, and because nearly all the materials with which it has to deal in its systematic co-ordination have been collected within the last quarter of a century.

The scientific spirit strives always to ascend from the special to the general; from multiplicity to unity. The Greek philosophers looked, in turns, to each of their four elements—earth, air, fire, and water—as the basis of all things. Newton, in his "Principia," demonstrated many propositions which are applicable in all fields of physical investigation, but he used them only for explaining the motions of the various members of the solar system. He spoke, however, of an "ethereal spirit," as a possible medium in universal gravitation, but without giving any hint of believing that any of its properties were within the reach of physical research. Franklin's experiments in electricity furnished a foundation for electro-dynamics, and led to a belief, which is still widely held, that in the various forms of electrical manifestation the clew to all physical activity is to be found. Mayer, Joule, and their collaborators opened the gates of that fairyland of science which Tyndall has so admirably described in his "Heat as a Mode of Motion," and there are many who now believe that all material phenomena are susceptible of an explanation by thermo-dynamic laws.

The theory of the "correlation of forces," which teaches that light, heat, electricity, magnetism, and chemical affinity are all forms of a single energy, and that they all may be interchangeably converted, provided the proper conditions are observed, may be thought to imply that neither of the correlated sciences is entitled to any precedence over the others, but that each of them becomes tributary to the general science of universal physics, so far as it develops laws which are of universal application.

Sir John Herschel appears to have been the first investigator who ever proposed any numerical estimate of the energy of light. It is a well-known proposition that the velocity of wave propagation, in elastic media, varies directly as the square root of the elasticity and inversely as the square root of the density. He accordingly stated, in his "Familiar Lectures on Scientific Subjects" (pp. 281–3), that the elastic force of the air, in its resistance to compression, would require to be increased "*in proportion to the inertia of its molecules*" more than 1,000,000,000,000 fold, to admit of the propagation of a wave with the velocity of light, and that this enormous physical force is perpetually exerted at every point through all the immensity of space. He also said (p. 218): "It must be remembered that it is Light, *and the free communication of it from the remotest region of the universe*, which alone can give and does give us the assurance of a uniform and all-pervading energy."

In the eloquent extract which is quoted by Tyndall (*op. cit.*, 4th ed., section 757), Herschel had previously stated that "the sun's rays are the ultimate source of almost every motion which takes place on the surface of the earth." Tyndall, with equal eloquence (*ibid.*, section 724), describes the flux of power which "rolls in music through the ages," and shows that all "the integrated energies of our world . . . are generated by a portion of the sun's energy which does not amount to $\frac{1}{2300000000}$ of the whole."

These extracts seem to furnish a sufficient reason for looking upon solar radiation as the basis of all terrestrial physics, and upon radio-dynamics, or the science which refers all physical activity to centers of energy, as the universal physical science. Gravitation, cohesion, and chemical affinity are directly concerned only with centripetal phases of force; inertia, in orbital and explosive motions, introduces a kind of centrifugal action; heat, properly speaking, seems to be wholly centrifugal, for the approach of particles when heat is radiated can hardly be attributed to thermo-dynamic action; electricity and magnetism, as positive and negative, boreal and austral, are both centripetal and centrifugal; light, according to the undulatory hypothesis, also represents both phases of activity, in the alternate contractions and expansions of wave propagation, as well as in the phenomena of radiation, refraction, reflection, and coloration.

Electricity and light have been connected, and to some extent identified, by means of investigations which were begun by Weber and Kohlrausch, in Germany, and continued by Thomson, Maxwell, Ayrton, and Perry, in England. As a result of those investigations, it has been found that electro-magnetism is related to electro-statics, somewhat as momentum to mass, the electro-magnetic unit being equivalent to the electro-static unit multiplied by the velocity of light.

Maxwell, accordingly, regarded light as an electro-magnetic phenomenon. It seems to me more logical to regard electro-magnetism as a luminous or radial phenomenon, for the following reasons:

1. Because the velocity of light is only one factor of electro-magnetism, but it is the important factor which constitutes it a force.

2. Because we have no evidence of electro-magnetic action in space, while we have much evidence of the action of light.

3. Because the eminent practical observers, who have studied the phenomena of terrestrial magnetism most carefully, have concluded that there is no specific magnetism in the sun and moon to influence the terrestrial magnetism through induction.

4. Because the mass-factor, which constitutes an important

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* Abstract of lectures delivered before the Franklin Institute, March 10 and 17, 1881.

though subordinate element in all thermal, chemical, electrical, and magnetic phenomena, is mainly, at least so far as it appears most obviously in those phenomena, a terrestrial factor.

5. Because it is better to designate the solar radiations by a name which will be universally recognized as appropriate, than by a name which has been generally applied only to local phenomena.

A still stronger and perhaps conclusive reason for regarding photo-dynamics as a special and principal department of radio-dynamics, is the fact that the velocity of light, as I propose to show you, is an important factor of gravitating, as well as of electro-magnetic action. In studying the phenomena of gravitation, there is no necessity for introducing any other elements than those of simple *vis viva*, mass and the square of the velocity. If the limit of efficient velocity can be shown to be the velocity of light in both departments, the law of parsimony would exclude the electrostatic unit, unless it can be shown that it is a necessary element of mass. This has never yet been done. If the necessity should be demonstrated hereafter, it is more likely that it will be found to depend upon some modification of the fundamental velocity of light than upon any independent activity which can be regarded as purely electrical.

The chief postulate of photo-dynamics may be stated as follows: *All physical phenomena are due to an Omnipresent Power, acting in ways which may be represented by harmonic or cyclical undulations in an elastic medium.*

The Omnipresent Power is scientifically required by the law of harmony; the harmonic or cyclical undulations, by the law of permanence or stability; the representative elastic medium, by the law of equal and opposite action and reaction. All questions as to the reality or nature of the supposed medium are of minor importance. Although my investigations have strengthened my own belief in the reality of an all-pervading ether, we are only required to recognize the existence of phenomena which involve such actions, and can be explained by such laws, as have been deduced from the motions of the atmosphere and other elastic fluids.

The following well known laws have an important bearing upon photo-dynamics:

1. Cyclical activities may often be accurately represented by formulas which introduce mean or average velocities and mean *vis viva*. This is the foundation of Maxwell's theory of the equality of mean *vis viva* in the molecular movements of different gases at equal temperatures, and of Pfaundler's discovery that in estimating the heat of dissociation, the mean should be taken between the temperatures of incipient and of complete dissociation.

2. The projectile force, which produces flight or cyclical motion against any central acceleration or retardation, is equivalent to the mean acceleration or retardation multiplied by one-half the time of flight or cyclical motion

3. The velocities of wave motion in elastic fluids, and of cosmical and molecular orbital motion, can all be expressed by a common formula.

4. Every periodic vibrating or orbital motion can be regarded as the sum of a certain number of pendulum vibrations.

5. Mean *vis viva* may be represented by the *vis viva* of centers of oscillation.

6. The distance of the center of oscillation from the center of relative stability is at two-thirds of the length of a linear pendulum, or at the square root of four-tenths of radius in a rotating sphere.

7. The acceleration of any force, which is uniformly diffused from or towards a given center, varies inversely as the square of the distance from the center.

8. Times of revolution, under the action of such forces, vary as the three halves power of the distance; distances vary as the two-thirds power of the time.

9. Centers of inertia, or nodes, in a vibrating elastic medium, tend to produce harmonic nodes.

10. The force of planetary projection should be referred to perihelion; the force of incipient subsidence, to aphelion.

11. The mutual interactions of cosmical, molecular, or atomic bodies are proportioned to the respective masses; actions which are considered with reference to a single active center vary directly as the mass and inversely as the square of the distance.

12. In elastic atmospheres the densities decrease in geometrical progression, as the height above the surface increases in arithmetical progression.

13. Living force, or *vis viva*, is proportional to the product of mass by the square of the velocity.

14. The distance of projection against uniform resistance is proportioned to the living force.

15. In synchronous orbits, the mean velocity of rectilinear oscillation is to the velocity of circular orbital oscillation as twice the diameter is to the circumference.

16. In a condensing nebula, the velocity of circular orbital revolution is acquired by subsidence, from a state of rest, through one-half of radius.

The following additional propositions may be readily deduced from the foregoing:

17. The acceleration or retardation of a centripetal force varies as the fourth power of the velocity of orbital revolution.

18. In cyclical motions, the resultant of all internal forces must be in equilibrium with the resultant of all external forces, at the expiration of each half cycle.

19. The modulus of cyclical motion is equal to the product of acceleration by the square of the time of a half cycle.

20. The sum of all external forces may, therefore, be represented (2) by a velocity which is equivalent to the mean or resultant internal force acting for one-half of the cyclical time.

21. At the extremity of a linear pendulum, the influence of a central force on the center of oscillation is nine times as great as on the center of suspension.

22. The limiting *vis viva* of wave propagation is five-ninths of the mean *vis viva* of the oscillating particles.

23. In condensing nebulæ, rupturing forces which are due to central subsidence may be represented by fractions in which the denominator is one greater than the numerator.

24. In synchronous rotation and revolution, the nuclear radius varies as the three-fourths power of the limiting atmospheric radius.

25. The variation in mean *vis viva* of gaseous volume is to the variation in *vis viva* of uniform velocity as 1 is to 1·4232.

26. The mean thermal and mechanical influences of the sun must be in equilibrium.

27. The collisions of particles, in subsiding toward a center of force, tend to form belts at the center of linear oscillation.

28. The limiting velocity between tendencies to aggregation and tendencies to dissociation is to the velocity in a circular orbit as the ratio of the circumference of a circle to its diameter is to the square root of two.

29. In explosive, as well as in cyclical motions, equilibrium must be established between internal and external forces.

30. Apsidal and mean planetary positions must also be controlled by like tendencies to equilibrium.

31. Undulations in an elastic medium maintain the primitive velocity which is due to their place of origination.

32. When two or more cyclical motions are combined, they must all be modified by the tendency to conservation of areas.

33. In expanding or condensing nebulæ, the conservation of areas maintains a constant value for the modulus of rotation.

34. Instantaneous action between different masses or particles by mere material intervention is impossible.

35. In synchronous motions about different centers, the mean distances from the centers of motion vary as the cube root of the masses or other controlling forces.

36. Constant velocities, in a homogeneous elastic medium, represent constant living forces.

In applying these general principles, we must expect to meet with perturbations, arising from the adjustment of opposing tendencies. If the problem of three bodies is so difficult, in astronomy, as to defy all efforts at satisfactory solution, the attempt to grapple with all the intricacies of elastic interaction may also defy the ordinary methods of mathematical analysis. And yet, by paying proper regard to mean values, it is possible, through very brief and simple processes, to get approximate determinations of important astronomical and physical constants, in which the error is less than in the ordinary approximations which require long, tedious, and intricate calculations.

Lockyer's late spectroscopic researches have awakened a new interest in the old theory, that all chemical elements are merely different forms of condensed ether, and that the ether itself is only a universal atmosphere. Taking this theory as a provisional hypothesis, there can be little question that hydrogen is the element which resembles the ether most closely, and which may, therefore, be regarded either as the first step in elementary condensation, or as the transmitter of primordial undulation. It is the lightest of all known substances; it is hyperelastic, being the only gas in which the elasticity increases faster than the condensation; it is always present in solar explosions, if the evidence of the spectroscope is trustworthy; the height to which it is thrown, and the rapidity of its diffusion, in these explosions, indicate a force and velocity which can be best explained by photo-dynamic influence; there are many reasons for believing that it is the outer envelope of the sun; and it presents many features of peculiar interest in connection with Lockyer's basic lines, which furnish simple harmonic indications of great significance.

In order to illustrate some of the properties of hydrogen I have prepared a pipe and some soap suds, for blowing bubbles, and by making a connection with the receivers I am able to inflate the bubbles with a mixture of oxygen and hydrogen.

You see with what rapidity the little balloons mount to the ceiling. I touch them with a candle and you are startled by their explosion. Doubtless most of you have seen the experiment before, and have learned that when the gaseous particles rush together, after the explosion, they are joined chemically so as to form water; but I think none of you have ever dreamed of any possible bond of union between the explosion and satellite revolution, or of weighing the bubbles in a scale with the sun. That there is such a bond, and that the sun can be thus weighed, I will try to show you.

Tyndall has told us (*op. cit.*, section 181) that the force of explosion, in one pound of hydrogen uniting with eight pounds of oxygen, is "equivalent in energy to the descent of a ton weight down a precipice 22,320 feet high;" it would, therefore, be sufficient to lift a ton to the top of such a precipice. If it were all concentrated upon the hydrogen alone, that gas would be driven entirely beyond the reach of the earth's attraction; but it carries with it the eight pounds of oxygen, and, notwithstanding this ninefold burden, if there were no resistance from the air, the watery vapor would be lifted more than two thousand miles before it would begin to fall to the earth again. The velocity with which it starts is more than five miles per second, or nearly one per cent. more than the velocity with which a satellite would revolve at the surface of the earth.

You have already learned that circular orbital velocity is acquired (16) by falling through half the distance to the center; therefore the combining energy of water is more than sufficient, if it were not for the resistances of the air and of friction, to keep it in perpetual revolution. Those resistances do not destroy the motion; they merely change it into heat, electricity, magnetism, chemical affinity, molecular vibration, or some other form of cyclical oscillation.

Do you think that these harmonies are merely accidental, or that they can be so regarded with any reasonable probability? In order to remove any possible doubts upon the question, I will ask you to follow me still further.

According to the kinetic theory of gases, the particles are in perpetual motion, and the gaseous elasticity is owing to the force of repeated collisions. You may accept or reject the theory as you please, but all the known properties of elastic fluids are such as they would be if the theory were true. It may, therefore, be safely assumed as a guide to new investigations. In subsidence from the satellite orbit of watery vapor, when the orbit velocity is increased twofold, the gravitating acceleration (17) is increased sixteenfold. Now, if we multiply this increased acceleration by the molecular velocity of hydrogen, the product is the same as if we multiply the original acceleration by the orbital velocity of the earth, so that the explosion of our soap bubbles furnishes us with all the data which are needed for weighing the sun and measuring its distance.

In order to make our approximations as close as possible, it is desirable to check, or confirm them, by finding some other harmony of a similar character. We look naturally, in the first place, to hydrogen's companion in its plunge down the mighty precipice, and we find that oxygen stands in a still closer relation to earth's velocity of rotation than that in which hydrogen stands to earth's orbital velocity. If we divide earth's equatorial circumference by the number of seconds in a sidereal day, we find that its rotating velocity is 1525·7 feet per second, which is precisely the velocity of oxygen, according to the experiments of Clausius, at the temperature of 4·8° C. This is within the limits of possible uncertainty of the temperature of water at its greatest density, the commonly accepted temperature being 4° C.

This harmony may be extended so as to include all gases through Maxwell's law of equality of gaseous *vis viva*.

Substituting atomic weight for gravitating acceleration, and remembering that orbital *vis viva*, in equal volumes, is proportioned to the gravitating acceleration, the mean velocity of hydrogen at 4·8° C. can be readily deduced from the mean velocity, at the same temperature, of any other gas of known atomic weight. If we adopt Regnault's value for the atomic weight of oxygen, 15·96, the mean distance of the sun is 92,769,000 miles; its mass 331,595; and the velocity of light is 186,400 miles per second. These results, though so simply deduced, are fully as trustworthy as any that astronomers have yet reached, after thousands of years of patient observation and tedious calculation.—*Franklin Journal.*

PHOTOMETRICAL RESEARCHES.

IN the last number of the *Journal de Physique*, Mons. A. Cornu commenced a series of observations on "Photometrical Studies" made by him, in consequence, as he says, of having found the necessity, in many branches of physical science in which he has been engaged, for some simple arrangement of apparatus for measuring luminous intensities. He announces the completion by himself of various photometrical and spectro-photometrical appliances which he believes will prove useful in many ways, both in physics and astronomy. Thes arrangements are based upon the property of lenses, discovered and utilized by Bouguer, that the form of a focal image is independent of the dimensions and form of the aperture of the lens, and of an intensity proportional to the surface of the aperture.

In the first form of apparatus, intended for the comparison of the intrinsic brilliancy of real images received upon a white screen, M. Cornu makes use of two achromatic object-glasses, as similar in all respects as possible, of which the principal optical axes cross each other at about their common focal distance. Each of these throws upon a white screen the image of a small rectangular diaphragm placed at the conjugate focus from the screen, and behind each of the diaphragms respectively is placed one of the two sources of light, or rather the portion of the luminous object of which the relative brilliancy is to be compared. The equality of the two images is obtained by varying the area of one of the objectives, and for this purpose each of the glasses is covered by two metallic plates sliding one over the other by the action of a pinion working in two ratchets. The orifices in the plates are square, and by revolving the pinion the two perforations are made to allow a smaller or larger amount of light to pass. As the holes are placed diagonally with each other, the movement of the ratchets always preserves a square opening, and as the pinion is fixed while its rotation causes the two plates to approach or separate the holes, it follows that the center of the square opening is always in the optical center of the lens. This is what is generally known as the "cat's-eye" arrangement of sliding screens.

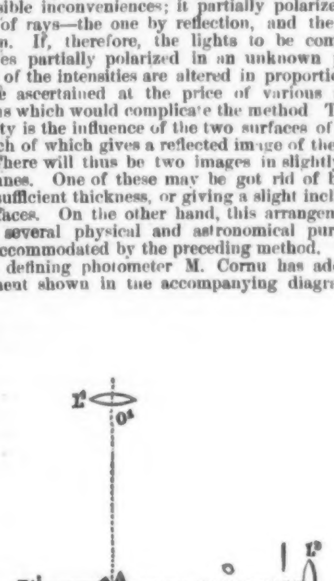
To measure two lights comparatively, the light-sources are brought as close as possible to the rectangular diaphragms, and their position is then regulated by two conditions. (1) The images on the screen should be as clear as possible, to effect which they must be advanced or receded by a convenient distance. (2) The opposite edges of the two images should coincide, so that the line of separation between the two fields may become invisible by the equality of the respective brilliancies. The points of luminosity which are to be compared must then be selected, and their images projected on the screen so that the edges are uniform. All being ready, the square diaphragm of the objective corresponding to the feeble light is opened to the full dimensions, and equality of the images is obtained by operating with the rack and pinion of the other diaphragm until the line of separation disappears. The diaphragms being provided with conveniently graduated scales to show the extent of the openings, the illuminating power is found by taking the inverse ratio of the squares of the graduation. The means of measurement may be infinitely varied by slightly diminishing the area of the diaphragm of the weaker source of light. A fresh point of departure is thereby attained, and by measuring the relative power of the two lights on this basis, a means of correcting the first result is obtained, the square of the difference thus shown being inversely proportionate to the relative power of the light, and so on. When the sources of light are very intense, the apertures of the two objectives may be diminished as required, to decrease the brilliancy of the images on the scale in order to better judge of their relative value.

It may happen that the two lights are not of the same color; in which case their comparison on a plain white screen is not precise. Similarity may, however, be restored by examining the two images through a colored glass of a tint having some relation to the use which is proposed to be made of the lights. To eliminate light inequalities of apparatus, the sides may be transposed; that which was at first used for the stronger light being used for the weaker, and *vice versa*. This is easily done in consequence of the construction of the apparatus, for in reality each part is fixed on the end of a large cylindrical pillar, which slides on a fixed internal rod. This arrangement permits of the principal axis of the objective being inclined, and of its being raised and lowered at will. As an instructive example of observation, the comparison of the intrinsic brilliancy of the middle of the flame of a flat-wick petroleum lamp with that of the same flame viewed edgewise may be named. It will be found that the brilliancy of the edgewise flame is more than ten times superior to that of the flat side of the same flame. To make this comparison, an auxiliary source of light is taken (such as a moderator lamp with a double current of air), and for the point of comparison an apparently homogeneous part of the flame is chosen, particularly the edge, which possesses a high and constant brilliancy. On the other side the petroleum lamp is fixed upon a support capable of revolving so as to present the side or edge of the flame in any direction. The brilliancy of the two aspects of the flame may thus be compared with that of the standard employed. The method of using an auxiliary or standard lamp, is, in M. Cornu's opinion, to be generally preferred to that previously described, since it eliminates all inequalities of construction of diaphragms or of transparency of objectives.

Another form of apparatus, called by M. Cornu the microphotometer, dispenses with the white screen. The preceding arrangement, modified by the substitution of a sheet of oiled paper or clouded glass, permits of the two images being observed from behind with the help of a magnifying lens, thus making the operation more easy and precise. Even this screen might be suppressed, and the images observed directly, these being, under such circumstances, infinitely more delicate and vivid; but as the principal axes of the two lenses form an angle of 15 degrees, the two images could not be observed simultaneously in the same position of the eye, because the two ocular rings are separate. The comparison is, therefore, difficult, and can only be rendered accurate by making the two axes of the objectives coincide. To accomplish this M. Cornu at first employed

the well-known means of a plate of plain glass at 45 degrees, which allowed the rays from one objective to pass by transmission, and brought forward by reflection the rays from the other objective. By suitable means of regulation the two actual focal images may be easily obtained in the same plane, to be observed by a hand-glass or a microscope of low power. The unequal proportion of reflected and refracted light does not permit, in this case, of a direct comparison of two light-sources; the auxiliary light must be used. The employment of this plain glass plate results in two possible inconveniences; it partially polarizes the two bundles of rays—the one by reflection, and the other by refraction. If, therefore, the lights to be compared are themselves partially polarized in an unknown plane, the relations of the intensities are altered in proportions which might be ascertained at the price of various subsidiary operations which would complicate the method. The second peculiarity is the influence of the two surfaces of the plain glass, each of which gives a reflected image of the source of light. There will thus be two images in slightly different focal planes. One of these may be got rid of by using a glass of sufficient thickness, or giving a slight inclination to the two faces. On the other hand, this arrangement lends itself to several physical and astronomical purposes not readily accommodated by the preceding method.

In his defining photometer M. Cornu has adopted the arrangement shown in the accompanying diagram. The



plain glass is replaced by the plate of black glass, A A, finished off by a straight edge, A, normal to the plane of the principal axis of the objectives. The focal planes, A F^1 and A F^2, are arranged to pass exactly by this edge. A microscope of low magnifying power (from 25 to 50 diameters) permits of the simultaneous inspection of the two images of the two luminous sources. By regulating as required the position of the sources of light, the two lighted areas to be compared are brought into contact with the edge of the glass. To render the comparison still more complete, the two areas are isolated by the aid of a circular diaphragm, C C', introduced into the optical plane of the microscope. The visible field will then consist of a small circle equally divided by the almost invisible line formed by the edge; one moiety will show a constant intensity, the other will be variable by the help of the photometrical screen. In these circumstances, and above all if care has been taken to bring down the intensities to a certain limit, the eye acquires such great sensibility, that the smallest differences of composition of the lights translate themselves by a difference of color which becomes irksome in the estimation of equality; none but sources of absolutely similar or monochromatic light give by this means a completely satisfactory impression of equality. The areas for comparison may be extremely minute; if the focal images are clear, and obtained by the aid of achromatic objectives, the microscope, acting as an eye-piece, will magnify them to any extent, and from the apparatus being thus applicable to the measurement of the brilliancy of extremely small images it has been called by M. Cornu the microphotometer.

This kind of photometer measures not only the intrinsic brilliancy of the focal image which is projected in the plane, A F^1, it also allows of the measurement, when the objective, L^1, is removed, of the lighting power exerted by any source whatsoever in the plane, A F^1. In fact, the intensity of a luminous wave tangent to the plane passing by the edge, A, and the path, A F^1, may be measured. It may be observed that this photometrical apparatus only fulfills its duty when the pupil receives all the light which has passed through the apertures of the lenses, or which comes from the luminous source; it is, therefore, necessary to verify, by the use of an additional magnifier, (1) that the minimum square aperture of the photometer, L^2, is entirely visible in the ocular ring; (2) that the aperture of the objective, L^1, or the image of the light-source, is also completely visible and concentric with the image of the square aperture. This form of apparatus is applicable to the measurement of the intensity of different parts of the spectrum by the use of a spectroscope in conjunction with the photometer.

M. Cornu promises further communications on this highly interesting subject, which is now attracting much attention in view of the admitted imperfection of existing kinds of apparatus.

DISEASES OF THE EAR.

FOUR CASES OF OTOMYCOSIS ASPERGILLINA SUCCESSFULLY TREATED BY THE INSUFFLATION OF OXIDE OF ZINC AND BORACIC ACID.

By SAMUEL THEOBALD, M.D., Baltimore, Md.

IN selecting an agent for the destruction of fungi in the human ear—more especially the frequently met with aspergillus—an important point is gained if we can find one that will not only eradicate the parasite, but will at the same time exert a beneficial influence upon the inflammation of the tympanal membrane and auditory canal which usually accompanies this condition. Alcohol, the remedy most commonly employed for this purpose, if diluted with water, is not, according to my experience, a trustworthy parasiticide, and if used in its anhydrous state is not always well borne, sometimes causing considerable irritation, and aggravating rather than benefiting the attendant inflammation.

For a long time I have been much given to employing oxide of zinc (usually in powder, though sometimes rubbed up with vaseline, with the addition of a little balsam of Peru) in the treatment of the chronic and subacute forms of diffuse inflammation of the auditory canal, especially in those moist inflammations attended by slight discharge, without perforation of the membrane, which I have met with oftenest in scrofulous subjects. More recently I have used, under similar circumstances and with still better effect, a powder containing equal parts of oxide of zinc and finely pulverized boracic acid. The knowledge which I possessed of its value in these cases, rather than any special convictions regarding its efficacy as a destroyer of parasitic growths, induced me to make use of this mixture not long since in a case of inflammation of the drum-head and inner extremity of the canal, due to the presence of aspergillus. The result of this experiment was so extremely satisfactory, and its repetition upon three occasions recently attended with such excellent effect, that I have thought my experience in this direction, though as yet limited, worth recording.

In each instance the method of treatment was the same: the ear was freed of all discharge, and, so far as possible, of every bit of the fungus, by means of the syringe and probe and then, having been wiped not too dry, the inner portion of the canal was filled, by means of an insufflator, with the zinc and boracic acid mixture. In two of the cases the additional precaution was taken of closing the ear with borated cotton after the application of the powder. The first case in which the treatment was tried was that of a young lady who had been under my care with recurrent furuncles in the external auditory meatus, and for whom I had directed vaseline to be applied to the orifice of the canal, to allay the itching which had followed the subsidence of the inflammation. Prior to this she had been instilling oleaginous drops (baume tranquille), in connection with which, however, I had prescribed frequent syringing. After using the vaseline for two weeks, she came to me complaining of some pain in the left ear and of slight discharge from it. (The vaseline had been applied to both ears, and so had the baume tranquille previously.) Upon examination the inner extremity of the canal was found to be covered with aspergillus, and when this was removed, marked congestion of the tympanal membrane and of the meatus-walls was revealed.

After careful syringing the boracic acid and zinc mixture was applied in the manner described. This single application was followed by the eradication of the fungus and the relief of the inflammation. When next seen, four days subsequently, nothing having been done to the ear in the meantime, she reported having had no return of the pain or discharge; the ear was found to be quite dry, and no trace of the aspergillus could be discovered. A portion of the powder, which had formed into a lump, was rolled out with a probe; and subsequently the rest of it, which adhered to the membrane and the sides of the meatus, was removed with the probe and syringe. The case remained under observation for two months, and there was no return of the aspergillus.

The appearance of the aspergillus after the use of the vaseline and the baume tranquille is worthy of remark. I am inclined to think that some of the latter was left in the inner extremity of the meatus in spite of the syringing, and that this, rather than the vaseline, was responsible for the development of the fungus. However, under similar circumstances, I should now add boracic acid to the vaseline, as it renders it more efficacious, and, as I believe, does away with all danger of its becoming a nidus for the development of the aspergillus-spores.

In the next case in which I had the opportunity of testing the boracic acid and zinc, its action was not less satisfactory. G. N., a fireman on board a steamboat, came to me with one ear completely blocked up with a mass of aspergillus. He had suffered no pain, but complained only of itching. After clearing out the ear as thoroughly as possible, the powder was freely applied, and the meatus plugged with a bit of borated cotton. The patient was not able to see me for a week, but during this time the cotton remained in position. Upon removing it the ear was found coated with the powder, and the aspergillus had entirely disappeared. Four months have since elapsed, and the fungus has not returned. The removal of the adherent powder was left to nature—the outgrowth of the epidermis of the drum-head and meatus-walls accomplishing this in due time more perfectly than I could have done.

The third case was that of a man employed in one of the railway grain-elevators of this city, who consulted me in November last for slight deafness of twelve months' duration, which a short time previously had become complicated by the appearance of a discharge from each ear, accompanied by soreness and itching. The deafness was found to be due to chronic middle-ear catarrh, and the other symptoms were accounted for by the discovery of aspergillus, in an early stage of development, coating the fundus of each ear. After careful use of the syringe and probe, which showed the tympanal membranes and inner portion of the canals to be much congested, the powder was applied as usual. At the end of a week the ears were again examined: the right one had given him no annoyance, was perfectly dry, and in it I could discover no remains of the aspergillus; in the left ear, however, there was still some discharge, and it was evident that the eradication of the fungus had not been complete. This one was again syringed, therefore, and the powder applied as before. After this both ears remained dry, and the aspergillus did not reappear.

The powder which adhered to the drum-heads and the walls of the canals was not syringed out, and as the patient has remained under treatment for his middle-ear catarrh, and has visited me once a week up to the present time, I have watched with much interest its gradual transportation to the orifice of the meatus, through the outgrowth of the epidermis. When last examined, but two or three small particles, just within the orifice of each canal, were all that remained of the powder which had been applied to the right ear eleven, and to the left ear ten weeks previously. *In this time, therefore—from ten to eleven weeks—the epithelium from the central portion of the tympanal membrane had accomplished its journey to the outer extremity of the meatus.*

The last case came into my hands but a short time since, and is still under observation. A girl, fourteen years old, of Irish parentage and correspondingly dirty personage, was brought to the Baltimore Charity Eye and Ear Dispensary with this history: from the left ear there had been a nearly constant discharge of purulent matter for eight or ten years, unattended by pain. In the right ear she had had recurrent attacks of severe earache, every month or two, for a period of two years, for which sweet oil and laudanum and sweet oil and black pepper had been applied from time to time. From this ear there was said never to have been any discharge. A recurrence of one of these attacks had induced her to come to the dispensary for advice, the pain during the previous night having been very severe. Upon looking into the right ear, several large and well-ripened heads of aspergillus were discovered springing from a whitish mass which filled the inner half of the canal, and which proved upon subsequent microscopic examination to be composed of mycelial rootlets and filaments; the heads showed the characteristic features of *A. nigricans*. In the other ear extensive destruction of the drum-head was found, with the usual appearances that accompany chronic otorrhea, and with no evidences of the presence of aspergillus. After careful removal of the fungus the zinc and boracic acid was freely applied to the right ear, and retained by the insertion of a piece of borated cotton.

This application was followed by the disappearance of all pain; but three days afterward, upon removing some of the powder with a probe, I discovered what seemed to be a remnant of the mycelial web, and finding some moisture beneath it, I again syringed the ear and applied the powder as before. Several weeks have elapsed since this last application, and as no trace of the fungus can now be discovered, and the ear has remained perfectly dry and free from all symptoms of irritation, I think we may safely conclude that the parasite, which it seems probable had found an abiding-place in the auditory canal of this girl for the space of two years, has been effectually eradicated.

I have mentioned that I was induced to employ the boracic acid and oxide of zinc powder in the treatment of otomycosis, by my experience of its usefulness in diffuse inflammation of the external auditory canal, rather than by any definite knowledge which I possessed as to its influence upon the vitality of aspergillus. In order, therefore, to ascertain whether it was capable of exerting a specific control over the development of fungi, or whether the good effects which I had obtained from it were due simply to its drying up the exudations from the inflamed meatus, and thus starving out, so to speak, the aspergillus, the following experiment was tried: four pieces of fresh horse-dung, one of which had been sprayed with a warm saturated solution of boracic acid, and then dusted with the finely powdered acid, and another sprinkled with oxide of zinc, were placed together under a glass bell, and kept in a warm room so as to promote the development of fungi upon them. The result obtained was very striking. In two days a luxuriant growth of pilobolus made its appearance upon the two pieces which had had nothing applied to them, and a somewhat less vigorous growth upon the one which had been dusted with zinc. The borated piece, however, remained entirely bare. On the third day one of the plain pieces, which was then covered with the rapidly growing fungus, was carefully sprayed and sprinkled with the boracic acid. In a few days the growth upon the unborated pieces increased greatly, especially upon the one which had not been dusted with zinc, and fruit-stalks, bearing myriads of spores, developed upon each of them. In the meantime, the originally borated piece remained, to all appearances, exactly as when first placed under the glass, and the fungus upon the other, which had succumbed to the treatment it received, showed no signs of revival. On the tenth day, at several points upon the second borated piece, the fungus began to show some vitality. It grew but little, however, and though watched for ten days after this, made no appreciable progress toward maturity. The piece first borated showed no growth upon it until the fifteenth day, when a single small tuft, scarcely larger than a pin's head, made its appearance. Three days afterward this growth, which presented the appearance of penicillium, the hardihood of which is proverbial, was removed for microscopic examination, but was not identified with certainty, owing to its undeveloped state. Though kept under observation until the twentieth day, there appeared upon this borated piece no other growth whatever.

While this experiment was in progress the last described case of aspergillus fell into my hands, and it occurred to me that, if I could cultivate the aural fungus after removing it from the ear, I might make a test which would be still more to the point. With this end in view, I preserved the pieces of the fungus (chiefly bits of mycelial web, with here and there a fruit-stalk) as they were removed, and, having kept them in water over night, placed them the next morning in a wide mouthed vial, upon a piece of white flannel soaked in rancid olive oil. The vial was then corked, put in a box to exclude the light, and set upon the mantel piece, where it would be kept warm by the heat of the chimney. In twenty-four hours each of the four pieces which had been transplanted began to grow, and in another twenty-four hours dozens of fruit-stalks with fully formed heads (of a rich brown color at first, afterward becoming black) had developed upon them. Rootlets could be seen extending out in every direction into the flannel, and in forty eight hours more the flannel was dotted all over with fruit-bearing stalks. Boracic acid was now applied in powder and solution, and by tilting the vial all but one group of the aspergillus was kept for several hours immersed in a warm solution containing an excess of the acid. The water was then removed, leaving the fungus and the flannel about it crusted over with the acid. The effect of this was to permanently arrest all growth in the aspergillus which had been subjected to the action of the acid, while that which had been kept from contact with it (the flannel being soaked with oil prevented the solution being carried to it by capillary attraction) continued to grow for some days.

These experiments indicate clearly, I think, that at least one of the ingredients of the powder which I had employed—the boracic acid—does in fact possess the property of destroying the vitality of certain fungi. The other ingredient, the oxide of zinc, probably exerts no such specific influence; nevertheless, in the treatment of otomycosis, it serves, I think, in connection with the boracic acid, an important purpose, and I am disposed to attribute to its action in no small degree the good results of the treatment in the cases I have related, for not only is its influence upon the inflammation of the ear most beneficial, but by drying up the discharge it renders the survival of the fungus more difficult, and prevents the boracic acid from being diluted and washed out of the meatus. I may add that in one instance, before I began to employ boracic acid, I succeeded in curing a case of otomycosis by the repeated application of oxide of zinc alone, and that in another instance, in which I employed the boracic acid alone, the result was not so favorable as in the cases I have related, considerable pain following the second application of the acid, and not being relieved until the cotton with which the meatus had been closed was removed, permitting a considerable quantity of thin discharge to escape.—*American Journal of Otology.*

A CASE OF BOTTLE IN THE RECTUM SUCCESSFULLY REMOVED.

By L. A. RODENSTEIN, M.D., of New York.

CHARLES W., a coachman, had for a long time suffered with hemorrhoids. A friend and fellow-sufferer, as a last resort, recommended dilatation of the sphincter ani by the introduction of a bottle into the rectum. He obtained a six-ounce medicine bottle, broke off the neck, ground off the rough edges, and on the fourth of July, 1878, holding the bottle firmly by its bottom, succeeded in introducing its conical end fairly into the rectum. He was just congratulating himself that at last he had hit upon a sure relief, when, to his horror, the bottle slipped from his hand and disappeared in the gut. The distention of the bowel had created a vacuum which drew the bottle into the gut. He had introduced the bottle at 7 A.M., and had mowed grass all day. At 7 P.M. I saw him; he had already taken a dose of castor oil to bring on an evacuation in hopes of ridding himself of the bottle, but without success. I introduced my index finger into the rectum, and touched what seemed the bottom of a good-sized bottle. I insinuated one finger after another until I had introduced the whole hand. Vain efforts to grasp it and make traction caused it to ascend further up the rectum. The pressure upon my hand now became so great that it lost all sense of touch. I persevered, however, using first one hand then the other, but only to find that the bottle was being carried farther up, till it had become engaged in the sigmoid flexure, where it remained.

Four hours having been spent in these ineffectual attempts, two other practitioners were summoned to assist me. At first they repeated my efforts, but likewise without success. The patient was then chloroformed. Upon then introducing my hand into the relaxed bowel, I found that the bottle had passed along the descending colon, having overcome the constriction of the sigmoid flexure and had followed the transverse colon until it had become fixed in the right iliac fossa at the cæcal pouch. As for extracting it, it seemed out of the question save by operative interference. On external manipulation, to find the precise location of the bottle, I had no difficulty in locating it, and found the neck of it in the right iliac fossa near the cæcum. The idea was suggested that, as it had been pushed by my hand to its present position, it could also be pushed back by pressure from the outside. The patient was put on his left side, his knees being well drawn up to relax the abdominal muscles; one of my colleagues inserted his arm up to the elbow into the rectum to guide the bottle, and found it was at that moment lying lengthways in the transverse colon, which I also could plainly feel through the abdominal walls. I pushed and manipulated with all the force I dared use, my assistant, meanwhile, guiding with his inserted hand. We made rapid progress until we reached the sigmoid flexure, when we came to a standstill. It seemed at that moment as if we were again to fail, but I kept up a constant and strong pressure, aided by the patient, who had come out from the influence of chloroform and bore down constantly. By lying partly on the bed facing the patient, my fist pressing upon the opening of the bottle, my elbow resting upon my hip, and my feet braced against the wall, I was enabled to use all my strength; the obstruction finally yielded, and the bottle, or the patient, was soon safely delivered. There was resistance at the sphincter ani, but it was soon overcome.

The bottle was partly filled with liquid fæces; it proved to be an ordinary six-ounce bottle of the apothecaries', with its neck broken off, making a cylinder four and one-half inches long, and two and an eighth inches in diameter.

The following points are worthy of note in connection with this case:

1. The rapid distention of the bowel when the conical body was introduced.

2. The severity of the pressure upon the hand and arm when in the bowel, both by the sphincters and muscular coat of the intestine, paralyzing the hand and destroying the nicety of the sense of touch.

3. The folly of anæsthetizing the patient in the hope of rapidly grasping and extracting the introduced body, as in this case the bottle was thereby drawn further up into the bowel. But for the anæsthetic the bottle would not have passed the sigmoid flexure.

4. The value of the patient's efforts in bearing down in accomplishing the final delivery.

I might mention here that we made many attempts both to grasp the bottom of the bottle by forceps and also to engage its opening and draw it down by means of hooks of different sizes and shapes, but they were useless.

I append a few of the most noted cases of foreign bodies in the rectum.

Dr. Weigand, of Würtemberg, relates a case of a farmer who introduced a cylindrical piece of wood (the end of a bean pole) five inches long high up in the rectum; was treated by castor oil, and the wood was expelled after thirty-one days.

Dr. Dahlenkampf, of Heidelberg, reports the case of a man, sixty-five years old, who, when in the woods, was compelled to stool; while in a crouching position his foot slipped and he fell. He felt a sharp pain in the anus and also in the rectum, from that time had difficulty in defecation, and only rested by lying on his belly, and not until ten years afterward was a piece of oak with the bark still on, four and a half inches long, removed.

Dr. Tompsett removed, by means of a long polypus forceps, a match-box six inches in circumference and two and a quarter inches in length. Desault's case of a man æt. 47, who entered the Hotel Dieu to have a crockery vessel extracted from his rectum. This vessel was a preserve jar, the handle of which was broken and the bottom detached. It was conical in shape, two inches in diameter and three inches long.

1838. Cumano extracted from the hollow of the sacrum a two-inch bottle by means of forceps.

1848. Parker reports a unique case of a man æt. 60, who, in a house of prostitution, forced a goblet two inches and a half in diameter and three inches and a half long into the vagina of his partner. She, for revenge, when he was completely intoxicated, pushed the bottom of the goblet into his rectum until the entire goblet had disappeared. It was removed by breaking it and taking it away by piecemeal.

18?8. A person æt. 40, introduced a wooden pepper-box, one and a quarter inches long and one inch wide, in his rectum; had done so for twenty years; at last had to be removed by forceps.

1835. A young man contemplating suicide introduced a fork in his rectum; violent pain which he had suffered made him repent and obtain aid at the Hotel Dieu.

In the history of the American war a sailor, who introduced into the rectum a stone five and a quarter inches long and three wide, was relieved successfully by gastrotomy.

1878. Studsgaard related the case of a postman who, in order to check an annoying diarrhea, introduced into the rectum a mushroom bottle, neck uppermost; he was anæsthetized with chloroform, but the bottle which, previous to the narcosis, had been felt in the rectum, slipped further up; the bottle could be felt through the abdominal walls along the median line on the left side, the bottom being near the horizontal ramus of the pubis; laparo-enterotomy, through the median line, was successfully performed. The bottle was seventeen centimeters long and five in diameter.

1858. Mr. Sacy removed from the rectum of a lady, piecemeal, a mass fifteen inches in circumference, consisting of concentric layers of a compound of earthy and ferruginous matter, with many thousand strawberry seeds.

The late Professor Charles Budd presented a specimen at the New York Obstetrical Society—a mass of fæcal accumulation, over fifteen inches in circumference, which he extracted from the rectum of a lady; she had suffered for months, and had been treated for chronic diarrhea. The mass had a hole in the middle, through which a continuous liquid discharge was passing. The obstruction was removed in two parts by means of the short obstetrical forceps.

Nolet relates the case of a monk who, in order to relieve himself of a violent colic, introduced into his rectum a bottle of Hungarian wine, having previously made a hole in the cork to admit the wine into the intestine. It slipped out of his fingers, and a small boy was found to introduce his hand; he reached the bottle and drew it out.

1813. Tuffell removed a flask of crystal from the rectum of a patient, but was obliged to break it in removal.

1777. Buzzani extracted from the rectum of a man a teacup; it had to be broken.

Morand removed, with a pair of lithotomy forceps, from the rectum of a man sixty years old, a large knitting-sheath of boxwood, six inches long.

M. Bonhomme extracted from a weaver, who had long suffered from constipation, a shuttle with its roll of yarn.

Marchetti mentions the often told story of the students of Göttingen, who introduced into the rectum of an unfortunate woman all excepting the small end of a pig's tail, from which they had cut enough of the bristles to render it as rough as possible; it was successfully removed by pushing a hollow reed over the pig's tail, thereby protecting the anus and removing the offending cause easily.

Constance relates the case of a man who fell on an inverted blacking pot, forcing it up his rectum. The pot was removed in pieces after breaking it.

Mr. Thomas relates the case of a gentleman who, by the advice of a physician while in Paris, introduced a flexible cane, about the thickness of a finger, daily into his rectum for the purpose of overcoming obstinate constipation. This plan worked well, and excited a stool regularly, until one morning, being in great haste, he carelessly forced it up farther than usual, when it was suddenly sucked out of his hand up into his body beyond the reach of his fingers. Severe pain set in, an examination was made, and the upper end of the stick was plainly felt through the parietes of the abdomen midway between the ilium and the umbilicus on the left side; this end had evidently passed through the sigmoid flexure and entered the tract of the transverse colon. This case was treated by cathartics until the lower end could be reached by the hand and extracted; its length was nine and a half inches.—*Annals of Anatomy and Surgery.*

ON FILTH AND SEMI-FILTH DISEASES.

By JOHN C. PETERS, M.D., New York.

I HAVE coined the name semi-filth diseases, in order to cover a large class of disorders which may arise from other causes, but in which filth is only too often a large factor.

The great sources of filth in large cities are dirty streets and gutters; the large quantity of filth which is washed down into the receiving basins and sewers with every rain storm, and the fouling of dock grounds and water by the contents of the sewers. There is every reason to believe that more filth in the shape of garbage and slops gets into the sewers from filthy streets and gutters than from water closets and kitchen sinks, and that a very large proportion of sewer gas is thus caused by filthy streets and gutters. Next in order is the vile odor from outdoor privies, many of which are without any ventilation, having neither windows nor chimneys. The health authorities are only too often remiss in their attention to these nuisances. London has one water closet for every five inhabitants. It is not at all uncommon to find water closets, even in otherwise good houses, without windows or other means of ventilation except by the door only, which must of course be kept closed when in use. Dirty cellars and foul air streaming up from the gutters into the air boxes of almost all houses, are other sources of household sickness. The stables of great cities are only too often in a filthy condition, and in this they are very rarely inspected by the health authorities. The smokes and smells from gas and ammonia works, from offal-rendering establishments, and the making of fertilizers, are pregnant sources of discomfort and disease. It is, perhaps, not commonly known that the fertilizer-making establishments, which cause so many mal-odors in this city, use ground bones, blood, all the offal and scrap, and the contents of the bowels of slaughtered cattle. These are first boiled, then dried, and much foul gas from them is not consumed but escapes from the chimneys, and are generally attributed to Hunter's Point.

Foul air must first attack the throat, air passages, and lungs. Diphtheria has often been traced to sewer gas, but much more commonly arises from foul streets, gutters, drains, receiving basins, etc.

Although it and membranous croup are often apparently excited by cold, yet they more commonly arise from cold taken in foul air, and must be regarded as partial or semi-filth diseases. In 1880 72 deaths occurred from diphtheria in January; 77 in February; 65 in March; 81 in April; 76 in May; 61 in June; 89 in July; 97 in August; 125 in September; 199 in October; 234 in November; 214 in December. So that they have some other factor besides cold, and that probably is filth.

Consumption is generally regarded as a chronic catarrhal pneumonia, most often caused by cold and insufficient clothing; but in 1880 there were 402 deaths in January; 375 in February; 412 in March; 394 in April; 365 in May; 351 in June; 385 in July; 380 in August; 376 in September; 408 in October; 339 in November; 450 in December. The deaths are so evenly distributed through every month in the year, that there must be some other cause than exposure to cold, and that cause is probably the inhalation of foul air. Bowditch gained great credit for apparently proving that consumption arose from moist ground; but foul moist-ground is probably a greater factor, and the inhalation of foul dust and dirt is not far behind it in deleterious effects.

Pneumonia, also, is generally attributed to exposure to cold and wet; but in 1880, 261 deaths occurred in January; 248 in February; 266 in March; 375 in April; and 340 in May. So that it also has another factor than mere cold, and that doubtless is the inhalation of foul air. It is true that only 163 deaths occurred in June; 127 in July; 108 in August; 134 in September; but in those months the city is largely depopulated; 205 deaths are recorded for October; 266 for November; and 349 for December.

From bronchitis 106 deaths are recorded in January; 122 in February; 140 in March; 188 in April; 131 in May; and 102 in June, so that bronchitis has other causes than taking cold, and foul air bronchitis and pneumonia are well known diseases.

Typhoid fever is generally accepted as a filth disease; typhus fever arises from the over-crowding of filthy people, and is at least a semi-filth disease. Cholera is a well known filth disease, and cholera infantum arises as much from foul hot air as it does from spoiled food or mistakes in diet, and is at the very least a semi-filth disease. Yellow fever is now generally admitted to be a filth disease, prevalent only in dirty cities and places, and all malarious diseases are necessarily foul air or filth diseases.

Civic malarious diseases, arising from the combined influence of foul ground and subsoil, foul streets, gutters, drains, receiving basins, cellars, back yards and privies, and other baneful influences, are certainly filth diseases. Pure, fresh air and free ventilation are necessary in the treatment of all diseases, and foul air increases the malignancy and mortality of all infectious and contagious diseases, including smallpox, measles, scarlet fever, diphtheria, whooping cough, typhus and typhoid fever, and many others.

These positions are so true as to be regarded as axiomatic by all except exceedingly old-fashioned medical men or obstinate officials. Let the Street Cleaning Department give us clean streets, gutters, and receiving basins, and the Board of Health give us wholesome outdoor privies, clean stables, control noxious trades far better than it does, and abate the loathsome smokes and smells which abound here, and then the death and sick rate will rapidly fall. The unhealthy condition of the city may be very equally charged upon the negligence of both these departments.

Puerperal diseases are attributed to other causes besides taking cold, yet we find 40 deaths recorded in January, 1880; 32 in February; 37 in March; 49 in April; 42 in May; 24 in July; 24 in August; 37 in September; 24 in October; 20 in November; and 45 in December.

The acclimatization to filth is a curious problem. Some people become accustomed to it, and thrive as well upon it as others do on tobacco and whisky; but 3,469 children died of diarrheal disease in 1880, and no less than 14,690 children died under five years of age. The great majority of these lived not only in poverty, but in filth. The deaths of children in filthy cities reaches enormous proportions, and those who survive may thrive like rose bushes and potato plants in manure heaps.—*Medical Record.*

CHRONIC TOBACCO INEBRIETY.

By DR. A. B. ARNOLD, M.D., of Baltimore, Prof. of Clinical Diseases of the Nervous System.

THERE exists considerable diversity of opinion respecting the effects of the habitual use of tobacco. Exact observations upon this point are still wanting. Those who deprecate even the most moderate indulgence in the weed seem to be influenced by the fact that nicotine is one of the most virulent of vegetable poisons; while others doubt the occurrence of a morbid condition resulting from this practice, because it is not readily recognizable in ordinary cases of smoking, chewing, and snuffing. Although it must be admitted that in the great majority of instances these modes of using tobacco are but seldom followed by serious impairment of health, it is, on the other hand, undeniable that certain well marked symptoms arise from continued consumption of small doses, that deserve to be designated as cases of chronic tobacco poisoning. A brief account of the results obtained by poisoning animals with nicotine, and by watching persons under the influence of dangerous doses of tobacco, will show more definitely the morbid tendencies of this noxious agent. At first there is a short stage of excitement, which is soon succeeded by a deep depression of the nervous system, characterized sometimes by clonic and tonic spasms. This is followed by extreme relaxation of the voluntary muscles, abolition of reflex action and of electric excitability, stupor, insensibility, contraction, and finally dilatation of the pupils. The respiration is shallow, and a thoracic constriction is felt. Failure of the heart's action, preceded by a short period of cardiac excitement, supervenes, and also griping or crampy pain of the bowels, frequently follow by bloody stools. These symptoms indicate serious implication of the centers of respiration and circulation, leading to paralysis, the immediate cause of death being asphyxia. The novice, when indulging in his first cigar, suffers from the effects of nicotine in a moderate degree, but in no less decided a manner; indeed, he closely presents the picture of seasickness. Nausea, giddiness, and a sensation of tightness across the chest which soon amounts to dyspnœa, and a kind of pain resembling angina pectoris are the first symptoms. Then ensue extreme pallor of the face, a cold sweat on the forehead, flickering before the eyes, singing in the ears, slight tremors, headache, colicky pains, labored respiration, a small, rapid, irregular pulse, somnolence, faintness, and a feeling of general misery, or of impending dissolution. A copious flow of saliva, vomiting, and frequently free evacuations from the bowels soon give relief. The tolerance of repeated and increasing quantities of tobacco which is rapidly established is an interesting phenomenon, and explains the apparent immunity from its effects. Traube experimented with an injection containing one twenty-fourth of a drop of nicotine, and four days afterward it required a whole drop to produce effects similar to those of the first dose. One of the most marked symptoms in these experiments was increased muscular excitability, which on larger doses developed tetanic contraction and muscular tremor. It is impossible to study the effects of nicotine upon the sensorium in animals, but there cannot be a doubt that tobacco exerts a direct influence upon the hemispheres. This is evidenced by the calming or soothing effects which small quantities produce upon the mind; and the occurrence of a species of inebriety that may terminate in stupor and insensibility when excessive quantities are used. The vertigo and want of co-ordination of the voluntary muscles must be referred to disturbance of the central ganglia. The implication of the spinal cord is shown by the tremor and tonic spasms; and the interference with the respiration and circulation proceeds from the abnormal condition of the medulla oblongata. Claude Bernard has shown that the motor nerves completely lose their electric excitability when large doses of nicotine are given.

According to Vulpian and Jullens, the striped muscles do not appear to be affected, for when their nerves were cut during the stage of paralysis from nicotine, it was still possible to evoke muscular contraction by mechanical stimulants. The unstriped muscles evince even a greater susceptibility to the influence of tobacco than the striped. It is highly probable that the asthmatic symptoms result from spasmodic constriction of the small bronchial tubes; and it is quite certain that the vomiting, the enteralgia, the augmented peristaltic action of the bowels, and occasionally the frequent micturition and uterine colic are due to an increased arterial tension, which has been experimentally demonstrated.

It thus appears that the sympathetic ganglia are likewise influenced by the use of tobacco. Robin ascribes the fatal result from nicotine poisoning to the inability of the blood to absorb oxygen, but this can hardly be the correct explanation, for artificial respiration sometimes succeeds in averting death; and furthermore the convulsions and the paralytic condition of the respiratory muscles permit a sufficient interchange of gases. The action of the heart is eminently influenced by the toxic effect of nicotine, and has for this reason attracted much attention. In very small doses it causes a remarkable slowness of the cardiac impulse, which may cease altogether during the diastole After a short time, when large and sometimes even small doses are used, an increase in the force and frequency of cardiac contractions takes place. This is succeeded by a gradual weakness, retardation and irregularity of the pulsations until they cease entirely; but the heart continues to beat for five or six minutes after the respiration has stopped. Recent pathological experiments have led to the conclusion that the heart symptoms in nicotine poisoning are due to the disturbed inhibitory function of the vagus nerve, and an abnormal state of the musculo-motor ganglia of the heart. Some of the secretions are undoubtedly augmented under the influence of nicotine. This is observable in the increased flow of saliva, the more copious discharge of bronchial mucus, and the freer transpiration from the skin. It is next of importance to consider whether the symptoms characteristic of acute nicotine poisoning are manifested, though in a far more moderate degree, in the habitual use of tobacco in any of its forms, or from the inhalation of the dust to which workmen in tobacco establishments are exposed. From all accounts it appears that smoking is the readiest way of absorbing the largest amount of nicotine, especially if the smoke be inhaled, as is the fashion among those who use cigarettes. Chewing is not a very obnoxious mode of indulging in tobacco, for the nicotine is readily dissolved in the saliva, and thus the greater part of it is thrown out with the spittle. According to general experience, it seems that the habit of snuffing is the least injurious mode of using tobacco. The continued irritation of the nasal mucous membrane appears to cause changes in its structure which, in the course of time, prevents the entrance of nicotine into the system. Nor are there any reliable observations which would confirm the belief in the resulting noxious effects of tobacco inhalation in the preparation of its various fabrics. There certainly exists a unanimity of opinion among observers, that the prolonged and large consumption of tobacco by smoking gives rise to unmistakable symptoms of chronic tobacco poisoning.

In a number of such published cases we find particular mention of physical disturbances, characterized by hebetude and incapability for sustained mental activity, or an exhibition of unusual timidity and pusillanimity of conduct. Ophthalmological journals report instances of defects and disturbances of vision which are ascribed to the use of tobacco. Hutchinson, in his hospital reports, gives cases of amblyopia from this source which were accompanied by somnolence, vertigo, and headache. Ophthalmoscopic examination detected paleness of the disk, diminished caliber of the arterial branches, and in advanced cases atrophy of the optic nerve, terminating in complete blindness. Wecker observed restoration of sight in those cases where tobacco smoking was abandoned, and asserts that the cure was assisted by strychnia in the temporal region, and the application of the interrupted current. Raymond ascribes these cases of amblyopia to the combined effects of tobacco and alcoholic stimulants. Hyperæsthesia of the different sensory nerves is very common, and it is well known that tobacco smokers suffer from neuralgia. Motor disturbances of every description have been traced to the immoderate use of tobacco, such as muscular weakness, especially of the lower extremities, tremor, ataxic movements, and cramps in different portions of the muscular apparatus. For the past few years I myself have been much addicted to smoking, which brought in its train a variety of symptoms of a very unpleasant character. In my case, the effects of tobacco were apt to be felt more particularly when lying down to sleep, consisting of the most part in increased action of the heart, throbbing of the temporal arteries, and flushes of heat over the head and face. But the most troublesome symptom, which fortunately made its appearance not quite so often, was a choking sensation of an alarming character, though only of a moment's duration. Probably it was caused by spasm of the glottis. Occasionally I was startled, just when drowsiness came over me, by a sensation as if some one had given me a hard slap upon the side of the head. At longer intervals I suffered in the morning, while yet in bed, from cramps of the calf of the right leg and in the sole of the foot on the same side. Stretching of the limb, I found, favored the occurrence of these local spasms. Distention of the stomach with flatus was another annoying symptom, to which I ascribed the dyspnœa from which I suffered much. It seemed to me that eructations, which I learned to bring on at any time, very frequently prevented the occurrence of some of the symptoms I have mentioned, especially the sudden onset of the choking sensation. Perhaps the latter phenomenon is a reflex action from gastric irritation. My appetite has never suffered, though I discharge quite a quantity of saliva during the act of smoking. The best reason I can assign for my belief that these symptoms were caused by tobacco, is the fact that on abandoning its use I was free from them. Lately I began to smoke cigarettes for the purpose of limiting the quantity of tobacco used; the evil effects of my previous immoderate indulgence are thereby not lessened, which warns me to abandon the habit entirely. The depressing effect of the inordinate use of tobacco upon the generative function is an old observation: indeed, it was considered the best antiphrodisiac remedy in the Italian convents of a past age. Wright, Clemens, and Foussard recently reported cases of impotency caused by the excessive use of tobacco. The latter authority describes a very annoying species of dyspnœa, generally occurring in the evening, which is not an infrequent effect of smoking. All accounts agree that disturbances of the heart's action is the most common of all symptoms in chronic tobacco poisoning. Richardson affirms that it aggravates the intermittence of the pulse which results from cardiac troubles. Retardation of the pulse under the influence of tobacco is probably due to its depressing effects upon the general nervous system. Angina pectoris may also be counted among the occasional effects of tobacco. Colicky pains, and sometimes violent cramps of the intestines, may be traced to the same cause. The popular belief that use of tobacco leads to dyspepsia does not seem to be well founded; at least in carefully observed cases of chronic tobacco poisoning, indigestion has not been noticed as one of its characteristic features. Chronic laryngitis is mostly observed among cigarette smokers, and it is probably due to the inhalation of the fumes. The question whether the use of the tobacco-pipe may cause cancer of the lips and tongue has been discussed by eminent surgeons. In view of the relative infrequency of this affection, which often locates itself in other parts than the mouth, and further, as persons suffer from cancer of the lips and tongue who never use tobacco, other factors must be presumed to co-operate in the production of the disease, although the existence of fissures and sores on the lips would commend total abstinence. Recent investigations respecting the chemical constituents of tobacco fumes confirm the older view of the presence of nicotine. It has, however, been ascertained that the nicotine appears mostly in the form of salts, having picoline for their base. Other substances of a similar composition are generated in the act of smoking, which seem to form under the influence of the varying quantity of water in the tobacco and its mode of combustion. Thus the use of the pipe develops the highly diffusible and narcotic pyridin, while cigar smoking gives rise to larger quantities of collidin. There exists only one remedy for the cure of chronic tobacco poisoning, but that is so prompt and efficacious that none other is needed. Unfortunately there exists also a very great and frequently an insurmountable prejudice among smokers against its employment. It is the abstinence from tobacco.—*Maryland Medical Journal.*

[Continued from SUPPLEMENT, No. 293, page 4678.]

THE CAT AND ITS RELATIONS.*

By FREDERIC A. LUCAS.

PROBOSCIDIANS.

The same features which excluded the cat from the Cetacea, exclude it also from the Sirenia, and we pass to the *Proboscidea*. This order contains the elephants, of which there are at present but two species, although formerly many more existed, varying in size from the mammoth, which stood thirteen feet high, to the little elephant, whose remains found at Malta indicated a height of only five and a half feet. Besides the proboscis, so characteristic of this order, and which enables these short-necked, unwieldy animals to feed alike from herb to tree, the proboscidea have a very peculiar dentition. The upper incisors are developed as tusks, and like the corresponding teeth in rodents, grow continuously, while they are destitute of enamel, like the teeth of Edentates. The molars succeed one another to the number of six, but instead of one tooth forming under another and replacing it from below, each molar forms behind its predecessor, and gradually pushes it forward, the front of the tooth in use being as steadily worn away.

HYRAXES.

According to Tennyson, King Arthur said:

"The older order changeth, giving place to new,"

and the animals which constitute the order of *Hyracoidea* are good illustrations of this fact. Once the hyraxes were classed with the rodents; next, although no larger than a rabbit, they were placed after the rhinoceros, and finally they were given an order by themselves. It may seem strange that they should have been so changed about, but part of the trouble, like many another, arose from trusting too much to appearances. From its small size and gregarious habits, and from the fact that its upper cutting teeth grow like those of rodents, it was put in that order. More careful investigation showed that its feet were armed with hoofs, not claws, and that its teeth and skeleton were far more like those of a rhinoceros than a rabbit, so it was shifted to the ungulates, and finally, on account of its peculiarities, set apart by itself. The hyrax has in some respects more backbone than any other mammals, for it has twenty-two ribbearing vertebræ and eight lumbars, a greater total number than is found in the sloths. The hyrax was known to the Jews, and the passage in the Bible which says, "The conies are but a feeble folk, yet make their houses in the rocks," refers to it.

HOOFED ANIMALS.

The great order of *Ungulata*, or hoofed animals, includes nearly all the large quadrupeds, and those most useful to man. Its members range in size from the hippopotamus to the tiny musk deer, no larger than a kitten. Among the noticeable forms are the rhinoceros, tapir, hog, horse, ox, deer, and giraffe. This order is characterized by the absence of a collar bone, by the presence of hoofs, and by grinding teeth of great complexity, formed of plates or folds of enamel embedded in dentine, and with the crown of the tooth never wholly covered with enamel. The canine teeth are usually absent, and there are never more than four complete toes on a foot. By the simple teeth completely cased in enamel, by the large canines—although this is not a certain distinction—by the presence of claws and of five fingers on the forefoot, the cat is separated from the ungulates.

CARNIVORES.

Our last order but one is that of *Carnivora* or beasts of prey. In them the collar bone is usually lacking, or, if present, is very small, the canines are large, and the crowns of the molars completely covered with enamel. The trunk vertebræ are almost invariably twenty in number, and the toes—never less than four—are armed with claws. Here evidently we have an order with which the cat agrees perfectly, and we decide that the cat belongs to the order of carnivora.

THE CAT A CARNIVOROUS MAMMAL.

Let us suppose now that we are going to construct an animal for a predatory life. We will make the skull small, so that it may not render the animal top-heavy. As our animal is to live upon other beasts, it will need sharp-edged teeth, and we will plant them in rather a short jaw, so that the muscles may have great power by acting on a short lever—the jaw being a lever of the third order. As we shall need powerful muscles to work the jaw, we must widen the cheek bone to give them room, and as the jaw will be exposed to severe strains by the struggle of the prey to escape, we shall so articulate it that it shall run but little risk of being dislocated. As our ideal animal may wish to carry its food to some secure place where it may feed in safety, we will give it very strong neck muscles to enable to raise and carry off its prey, and to furnish attachments for these, we shall have to roughen the base of the skull, and put long processes on the first dorsal vertebræ. The animal will need great freedom of movement in the fore limbs, so as to strike rapid blows, but at the same time we need power, and so we add sharp ridges, to which the muscles can fasten. Our animal must be able to spring suddenly on the creatures it lives upon, so we make the heelbone long, to give leverage, and put long processes on the lumbar vertebræ, to which we secure the leaping muscles. Then we will arch the foot bones, because sometimes the creature we are constructing may miss his leap, and we do not wish the shock of a fall to injure it. Finally, it ought to have pretty sharp claws, and that they may not bear on the ground, we will make them draw back when not in use. We have, we think, constructed a pretty good carnivorous mammal; and at the head of the order carnivora we find a family—the *Felidæ*—possessing all these characters. The cat, too, that we have been studying has them also; hence there can be no doubt but what it is of the genus *Felis*. We need but a name to denote just what felis our cat is, and, as we find that the cat has been domesticated since the earliest days, we call it *Felis domestica*, and thus complete its classification.

* A paper read before the Rochester Society of Natural Sciences.

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TABLE OF CONTENTS.